Spring 5-1-1969

A Study of Ant Populations at the Plains-Foothill Border

August Conklin
University of Colorado Boulder

12

Robert E. Gregg

A STUDY OF ANT POPULATIONS

AT THE PLAINS-FOOTHILL BORDER

by

August Conklin

B.A. University of Colorado, 1942

M.A. Claremont Graduate School, 1951

M.A. University of Colorado, 1962

A thesis submitted to the Faculty of the Graduate School of the University of Colorado in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Department of Biology

1969

This Thesis for the Doctor of Philosophy Degree by

August Conklin

has been approved for the

Department of

Biology

by

Robert E. Gregg

Erik K. Bonde

Date

Conklin, August (Ph.D., Zoology)

A Study of Ant Populations at the Plains-Foothill Border

Thesis directed by Professor Robert E. Gregg

Three quadrats, one hundred meters to the side, were located at the plains-foothill border region southwest of Boulder, Colorado, near Bluebell Canyon. One quadrat was in a wooded area, another in a meadow, and the third in an ecotone, half-meadow, half-wooded area. Ants were intensively collected in these quadrats for three summers, from 1965 through 1967. The summer of 1968 was utilized for soil moisture and temperature determinations, as well as for actual counts of ant colonies.

A total of 25 species and subspecies was discovered. Of these 25 species, nine were species found in two quadrats, which provide evidence of a distinct boundary between the lower edge of the foothill zone and the plains, since eight of these nine were found in the ponderosa pine forest and the ecotone, but did not penetrate the meadow. The other species was found in the meadow and ecotone, but did not penetrate the ponderosa pine forest. There were two additional species in the meadow and five in the forest which did not penetrate the ecotone.

The Lincoln Index was utilized in this study to determine its efficacy in estimation of the size of selected ant colonies. It was found to be inaccurate, since use of this index results in great underestimation of ant colony size.

Individual nest stability and nest number constancy were also examined. The majority of the 25 species and subspecies are quite unstable in their nesting habits, and nest number was somewhat inconstant.

Total counts of ant nests were made, and these, plus the number of nests of the various species, made it possible to determine the ecological dominants in each quadrat for each year. It was also found that there were more species of ants in this study in the wooded quadrat, which had a slope facing north by northwest, than in the ecotone or in the meadow. Observations were also made with reference to compound nests, polydomous nests, and species which have nuptial flights in late summer.

Soil moisture and temperature determinations were made in the various quadrats, and the probable causes for nest mortality or exodus were examined.

This abstract is approved as to form and content. I recommend its publication.

Signed ______________________________
Faculty member in charge of dissertation

ACKNOWLEDGMENTS

As the writer of this dissertation, I wish to express my heartfelt thanks and deep appreciation to all those who not only offered helpful suggestions and criticisms, but also provided considerable encouragement.

Special thanks must be given to the following:

To my wonderful family, especially to my wife, Jane, who not only gave me much needed encouragement, but spent many hours in typing the manuscript, and to my sons Tom and Jim. Without Tom, who was my invaluable good right arm in the field, this study would probably not have been accomplished. Jim also gave me encouragement when I needed it.

To Doctor Gregg, who not only made many beneficial suggestions, but also spent considerable time in assisting me with my ant classifications. Doctor Gregg's advice and contributions were invaluable to this project.

To Doctors Erik K. Bonde, John W. Marr, Charles H. Norris, Robert W. Pennak, Sam Shushan, and Hobart Smith with whom I had many pleasant and worthwhile associations, and who provided assistance as well as inspiration to my program.

TABLE OF CONTENTS

LIST OF TABLES

TABLE		PAGE

LIST OF FIGURES

INTRODUCTION

This investigation is a study of the ant faunal distribution of the plains-foothill area near Boulder, Colorado, and is concerned with the distribution of ants over a three-year period in three types of environments, namely, a forest, a meadow, and an ecotone of forest and meadow. All three of these environmental units are located at the plains-foothill border where there is a peripheral convergence of the grassland formation of the plains and the montane coniferous formation. The foothills consist of rounded hills, upturned sedimentary beds, and mesas, and near Boulder, the land forms are expressed as Mesa and Dakota ridge forms to which the border is confined. Gregg (1963) writes that the plains-foothill region is ecologically significant in that climatic conditions are typical neither of the plains nor of the foothills. Also, the topography is distinct, and a variety of soils are present.

In a review of the literature, no study strictly similar to mine was found. However, there are a few studies which embrace some of the objectives of my study in the areas of ant species distribution, nest stability, the use of the Lincoln Index as a tool for population census, and the effects of climate on ant distribution.

Many studies are concerned with distribution of ant species. Talbot (1934), for example, studied the distribution of ant species in the Chicago region with reference to ecological factors and physiological tolerances, and Barrett and Felton (1965) examined the distribution of the wood ant, Formica rufa Linnaeus, in southeast England. Brian, Hibble, and Stradling (1965) published a paper on ant pattern and density in a southern English heath, and Francour (1966) established the distribution of certain species of ants in the Quebec region. Wheeler and Wheeler (1963) wrote a volume on the distribution of ants in North Dakota. Wheeler and Wheeler (1965) reported distribution of Veromessor lobognathus in South Dakota, whereas Gregg (1963), in a large volume, described the distribution of the ants of Colorado. Creighton examined habits and distribution of many ant species in numerous articles and also wrote a comprehensive volume on the ants of North America (1950). In his book on social insect populations, Brian (1965) discussed the critical factors in ant distribution, which are food and climate. Pickles (1937 and 1938) described changes in ant nest distribution, and Brian (1952) worked on the replacement of nests under stones. Yasuno (1965) made a study of the stability of the ant populations in grassland at Mt. Hakkôda, Japan. Golley and Gentry (1964) in a study on bioenergetics of the southern harvester ant, Pogonomyrmex badius, comment on their findings about movements of the ant hills for that particular species. They learned that movement of ant hills was a common phenomenon, and these movements appear to be most common in the fall. Wheeler (1910) states that there are a few species of ants besides the nomadic Dorylinae that seem to "enjoy" an occasional change of residence. He writes of Wasmann, who has shown that Formica sanguinea often has summer and winter residences analogous to the city and country homes of wealthy people. Brian (1965) discusses the hazards which are present in helping to cause instability in ant nests and cites work done by Gösswald and Kloft (1961) in connection with damage done to ant nests by field mice. Brian (1965) delineates the modifying factors which affect the food supply, which, in turn, affects the stability of ant nests, and discusses interspecific and intraspecific competition as factors in stability of nests. Such competition introduces ant territorialism, which has been widely studied since Elton (1932) showed its existence in *Formica rufa*; Brian (1965) and Yasuno (1965) among others in the more recent literature, and Forel (1928) in the older literature, write on this subject. Pleometrosis, or the occurrence of more than one queen in a single nest of ants, is another cause for instability in ant nesting, and Schneirla (1949) and others have observed that pleometrosis has a considerable influence in the increase of population size. Schneirla (1957) found that the reasons for restlessness in the behavior of the Dorylinae in their characteristic nest instability are the need for food and their response to an internal brood change.

Stability of ant nests and the time of year for the nuptial flight, two objectives of my study, relate to ant movements for habitat selection. Wilson and Hunt (1966) examined habitat selection by the queens of two field-dwelling species of ants. These investigators concluded that major habitat selection is performed primarily during the nuptial flight but that the microhabitat (nest site) is selected only after searching on the ground following the flight. Talbot (1966) discussed flights of the ant *Aphaenogaster treatae* and found that this field ant has unusual flights, in that they take place at high temperatures (78° to 88° F), but only if light is reduced, either by continuous gray skies, or, more frequently, by moving clouds. Most flights take place when temperatures have been too high for workers to forage until clouds come by. Numerous studies have been made in ant behavior, and Sudd's book, An Introduction to the Behavior of Ants, describes many aspects of behavior in ants and provides an extensive list of references as well.

Numerous ecological studies have been performed on ants in the Boulder area or elsewhere in the State of Colorado, and beginning in 1910, W. W. Robbins of the University of Colorado Department of Biology made a survey of the ants of northern Colorado which was the first attempt to summarize the Colorado ant fauna. Periodically, since then, many species have been described from the state. L. F. Byars made an ecological study of ants in Boulder County in 1936 for his Master's thesis, and R. E. Gregg (1947) made a survey of ants in Colorado in a paper entitled "Altitudinal Indicators Among the Formicidae". E. D. Delfin (1954) conducted a general entomological survey in the Gregory Canyon area near Boulder, Colorado, and H. F. Borchert (1956) examined the distribution of ants of five canyon bottoms in the Boulder area. J. T. Browne (1958) did a Master's thesis study on ant distribution in Gregory Canyon, whereas M. E. Smith (1962) made a distributional study of formicids in the vicinity of Valmont Butte, Valmont, Colorado, near Boulder for a Master's thesis. W. H. Taussig (1962) also performed a Master's thesis study on ants in an ecological work on *Formica neorufibarbis gelida* Wheeler in the alpine tundra of Colorado, and, as mentioned previously, R. E. Gregg (1963) wrote a very detailed volume entitled The Ants of Colorado.

The Lincoln Index, which is a mark-recapture method of population census, has been used very extensively in fish and wildlife work, and according to Osburn (1953) the Lincoln Index was first developed by F. C. Lincoln (1930) to estimate North American duck populations. Jackson (1936), while studying tse-tse fly populations in Africa, derived, independently, a method identical to that of Lincoln's. The principle of the Lincoln Index is simple. A random sample of individuals is marked, and these are then released. Later, after a dispersal period, another random sample is collected and examined. The second catch may include a proportion of individuals recognized by their marks as having been caught in the marking period. The second catch should have the same proportion of recaptured insects to the total taken as the proportion initially marked to the total population.

$$\text{population size} = \frac{\text{total marked} \times \text{total caught when recapturing}}{\text{marked recaptures}}$$

Jackson's series of papers on tse-tse flies, reviewed by Andrewartha and Birch (1954), appears to present the first application of the method to insect populations, and in recent years this approach has been applied to many other insects such as butterflies, grasshoppers, locusts, and ground beetles; however, many investigators found the Lincoln Index was too crude to use without modification. Jackson (1939) and others recognized the need for consideration of birth, death, and migration rates, and Allee (1949) discussed limitations and advantages of the Lincoln Index. Odum and Pontin (1961) estimated the population density of the underground ant

Lasius flavus by tagging with radioactive phosphorus, and Golley and Gentry (1964) employed a similar tagging procedure with the southern harvester ant, Pogonomyrmex badius. The mark-recapture technique produced contradictory results. Chew (1960), who worked with Pogonomyrmex occidentalis in Arizona, used similar methods and did not achieve satisfactory results.

Odum (1959) states, "Temperature and moisture are so generally important in terrestrial environments and so closely interacting that they are usually conceded to be the most important part of climate." Knight (1965) states that the interaction of a number of climatic or microclimatic factors is most important ecologically, because it will often indicate why a particular organism is present or absent. In The World of an Insect by Chauvin (1967) the author writes that the German Rudolf Geiger once pointed out that what is taking place at a height of six feet has little bearing on what is happening by a man's feet, and therefore, the microclimate is extremely important to the insect. According to Gregg (1963) the two cardinal factors of temperature and moisture are correlated with the distribution of ants regardless of what else may be operating also, since it seems to be true that the number of species shows trends that parallel meteorological changes. Where conditions of temperature and moisture are both optimal, the greatest concentration of forms or taxonomic complexity are seen. Since so many ants are fossorial, they can obtain moisture deep in the soil, and therefore, temperature may appear to be more limiting for these, particularly a thermophilous group such as the Formicidae.

The literature on the subject of climate and insects is voluminous, as can be seen by examination of most texts of animal ecology, for example, Andrewartha and Birch's large volume (1954). However, very little information is available on the influence or importance of continuously varying humidities (Messenger, 1959). Messenger writes that rainfall is a major factor controlling the moisture content of soil, and therefore can be a major factor limiting the development and survival of some soil-inhabiting forms.

Wheeler (1910) says that the length of embryonic, larval, and pupal life in ants appears to be highly variable and to depend very intimately on temperature. A rise in temperature induces both females and workers to lay eggs and accelerates the growth of the larvae. Other factors being equal, development of eggs within the ovaries, the deposition of eggs, the feeding and growth of the larvae, pupation, and hatching all appear to be determined by temperature. The degree of heat suitable to the species probably varies for the different stages of development. Wheeler writes that the optimum temperature for northern ants lies between 70° and 80° F. At low temperatures, the exact level being different for each species, the insect comes to rest and shows no spontaneous activity; however, as temperature is raised, the ant becomes normally active, then excessively active, and ultimately passes into a state of heat stupor, followed by death.

Temperature, therefore, has a marked effect upon growth, and it also has an important effect upon metabolism. Wigglesworth (1965) writes that whereas the metabolism of warm-blooded animals is depressed as the external temperature rises, the metabolism of cold-blooded animals increases. The increased activity which the insect shows with rising temperature is an indication of the increase in metabolism. What happens to the extra energy produced in the resting, or narcotized, animal as the result of raising the temperature is not known, but much of it must be expended by the augmented movements of the internal organs. In the developmental stages of insects, the energy is expended on growth, which is correspondingly accelerated. Of course, the optimum temperature may vary with the humidity. Odum (1959) states that temperature and moisture interact upon one another but this interaction depends upon the relative as well as the absolute values of each factor. Thus, temperature exerts a more severe limiting effect on organisms when moisture conditions are extreme, that is, either very high or very low, than when such conditions are moderate. Likewise, moisture plays a more critical role in the extremes of temperature. Diminution in the water content usually depresses metabolism and retards development, and a lower relative humidity results in a longer period of larval development. Sometimes the effect of desiccation is purely mechanical; the chorion of the egg may become too hard for the embryo to break through, or the fully developed insect may lack sufficient volume of water in its blood to rupture its pupal sheath. Sometimes the rate of development is retarded at very high humidities. High temperatures cause greater evaporation through the integument, and may increase the permeability of the cuticle to water, which will result in water loss in insect eggs with a resultant decrease in population.

Ants have very definite responses to both temperature and humidity; for instance, Sudd (1967) states that early experiments with Aphaenogaster fulva, Camponotus pennsylvanicus, and Acanthomyops latipes showed that these ants moved sluggishly below 15° C. and that heat stupor began to set in at about 35°. They were rapidly killed by exposure to 50°, but inside this range they rest in a temperature of 24° - 27°. Sudd believes that ants are strongly affected by humidity and refers to their humidity sense. Low humidities cause death from excessive loss of water, especially when combined with a high temperature. At low humidities, earth-nesting ants simply retreat deeper into the soil. Larvae lose water to the air even faster than adults, and queens lose more water than workers, but pupae are far more resistant to dessication than the other stages. The workers transport the ant young from place to place, thus utilizing to the advantage of the developing young the ever-varying temperature and humidity of the soil.

The objectives of my study are as follows:

1. To present data to indicate that ants may offer significant evidence that the plains-foothill border is an important biological boundary.

2. To determine the stability and frequency of ant colonies from one year to the next.

3. To determine the value of the Lincoln Index in making a census of an ant colony.

4. To relate climate to ant distribution.

5. To determine foraging activities of some ants.

6. To examine the probable causes for exodus from an ant nest.

7. To note the various species of ants which live in compound nests (plesiobiosis).

8. To locate nests of ants which appear to have branched from the original colony (polydomous nests).

9. To census populations of ant nests and discover the probable dominants among ants in the area.

10. To discover which ant species in the research area have nuptial flights in late summer.

DESCRIPTION OF THE RESEARCH AREA

In the summer of 1965 three sites were selected for study. One of these three areas is in a meadow near, and northeast of, Bluebell Canyon, and the other two areas are on the slopes of a ridge east of Bluebell Canyon proper; these two are actually at the approaches to the canyon less than one-fourth mile from the canyon itself. All three sites are very near to each other, as evidenced by the fact that temperature readings for all three stations could be completed in 20 to 25 minutes. Each of the three locations was set up as a quadrat with 100 meters to a side. The meadow was designated as Q3 and had a gentle slope, which faced north by northwest (See Figures 1 and 2). Q2 was the symbol applied to a rather heavily wooded area, which had a sharper slope than that of the meadow, but it also sloped north by northwest. The wooded area was located in the ponderosa pine-grama grass community. Q1 was the ecotone, an area half wooded and half meadow, and it had a rather abrupt slope which faced east by southeast, but mostly east (See Figures 3 to 6).

Of the three research sites selected in this study, the forest, the meadow, and the ecotone, the forest and ecotone are in the Transition or Submontane Zone of Merriam (1898), which has an elevation of 6,000 - 8,000 feet (Gregg, 1963). The meadow is in the upper Plains or Upper Sonoran Zone, which has an elevation of 4500 - 6000 feet. Merriam also used other life zones for the division of North America into vegetational and forest units, but my

Figure 1. Q3—The meadow. View from the southeast.

Figure 2. Q3--The meadow. View from the northeast.

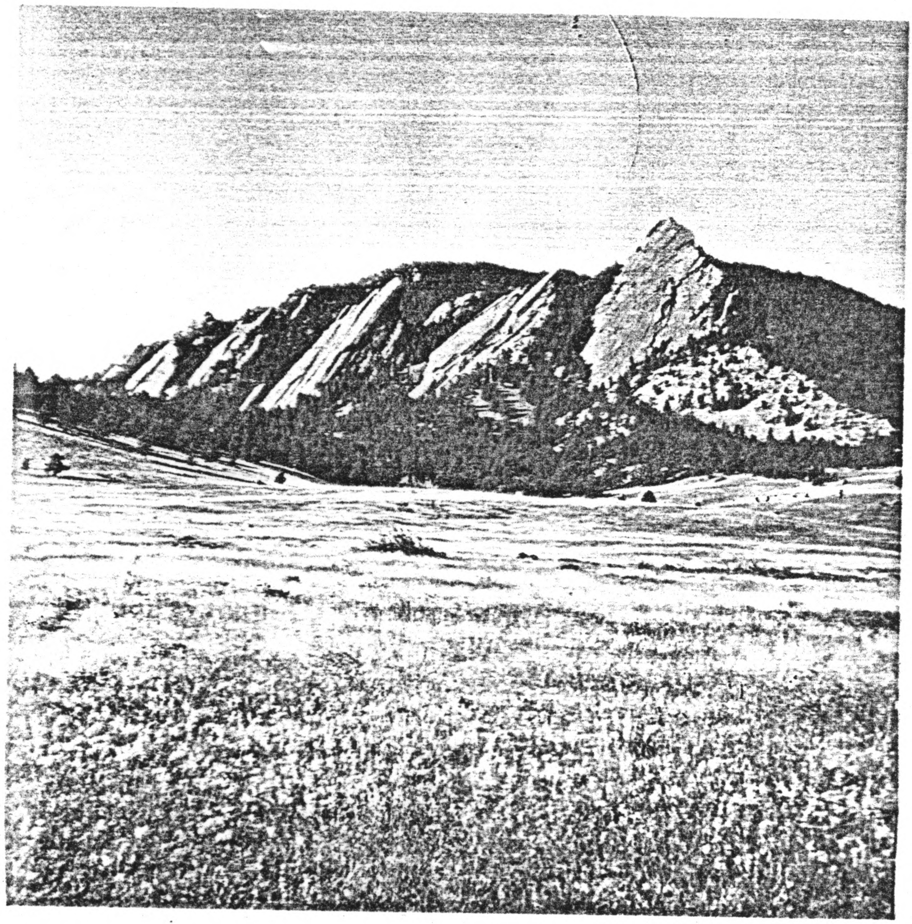

Figure 3. Q1--The ecotone. View from the southeast.

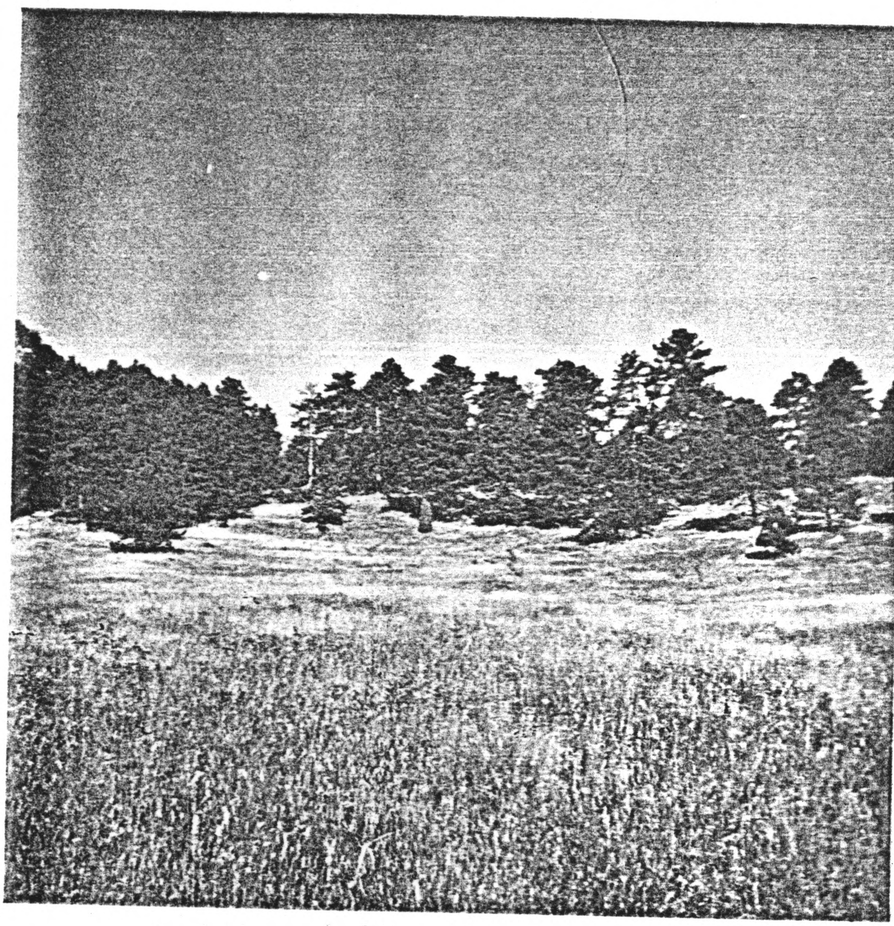

Figure 4. C1--The ecotone. View from the east.

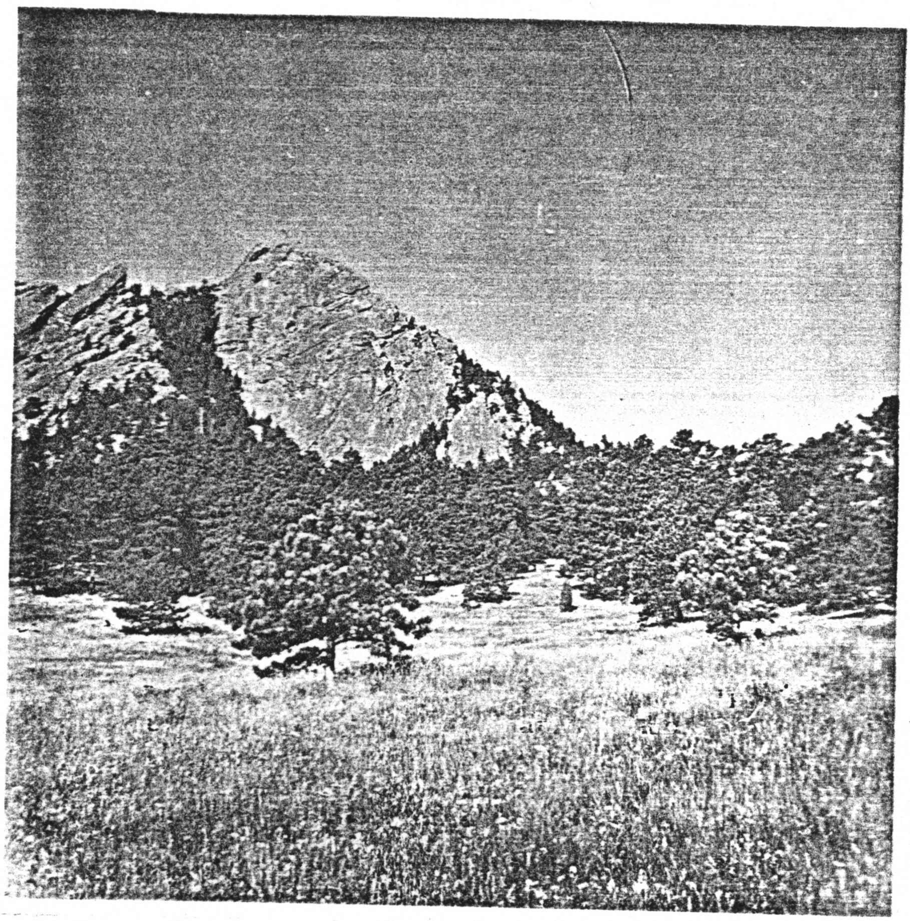

Figure 5. Q2--The wooded area. View from the north.

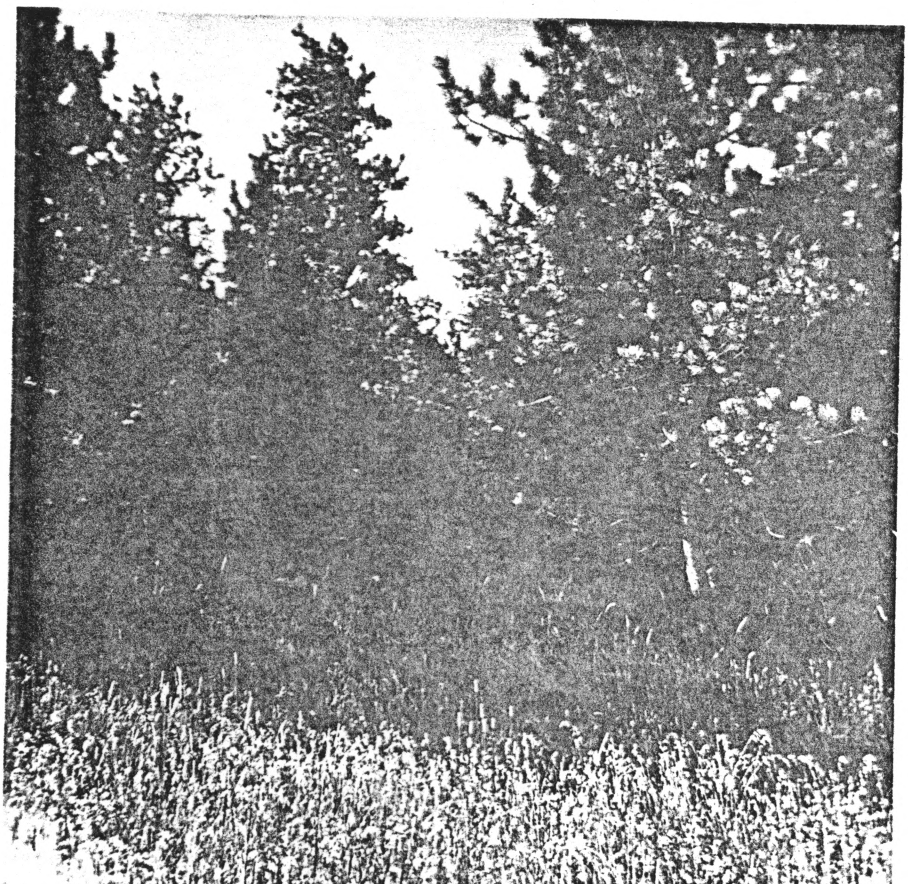

Figure 6. Q2--The wooded area. View from the east.

research area is not concerned with these other zones. Merriam's life zones were established on a climatic basis and set forth what he believed were temperature laws governing terrestrial distribution.

The area where I worked is at the southwest border of Boulder, Colorado, a city located 24 miles northwest of Denver at 40° north latitude, and 105° 16' west longitude. The front range of the Colorado Rockies rises steeply from the base of the foothills, which are approximately one mile high, to the Continental Divide 30 miles west of Boulder, which has mountains 11,000 to 14,000 feet in altitude. The mountain front can be divided into the foothills themselves, and a broad benchland, or mesa terrace, the benchland really being an upper extension of the plains.

Bluebell Canyon, which is found in the Transition Zone, has an approximate elevation of 6,050 feet, and has its mouth opening to the plains area. Its headwaters lie between the Flatirons, which are erect slabs of red sandstone on the east face of Green Mountain, and belong to the Fountain Formation. This formation was produced by deposition during the Pennsylvanian Period from 320 million to 280 million years before the present (Rodeck, 1964). The transition zone has many small intermittent streams, which are dry in the fall and winter, and the soils here are generally coarse-textured and shallow, with a soil water content which is usually low.

According to Byars (1936), the prevailing wind for Boulder County is westerly, having passed over the mountains; consequently, as the wind passes over the warmer plains, it takes up moisture and has a drying effect. The plains near the foothills are protected from the full force of the wind.

The climate of the plains near the front range of the Rocky Mountains, according to Armin (1963), is characterized by a relatively low humidity, a large amount of sunshine, light precipitation, moderate winds, a large daily range in temperature, high day temperatures in summer, and occasions when the temperature is subzero in the winter. As the distance increases from the foothills, conditions become moderately xerophytic. The nitrogen content of the soil and its organic nature increases with elevation, up to a certain limit, and there is a tendency for the soils to change from an acid to an alkaline condition from the alpine to the plains zone.

The climate of the foothills differs from that of the plains in general by having a narrower range of fluctuation of temperatures; higher minimum temperatures are found in the foothills region. According to Gregg (1963), in the Rocky Mountains the drop in average temperature with increasing elevation, or the lapse rate, is approximately 3° F. per 1000 feet, lower than this in the winter, and slightly above in the spring and early summer. Air drainage has a greater influence than elevation, for cool winds of the montane zone (elevation 8,000 to 10,000 feet) bring mountain temperatures to narrow canyons, but the slopes facing the plains have almost the same temperatures as those of the plains. Wide valleys are warmer than narrow ones, and slope direction is important, since south-facing slopes obviously are warmer and drier than the north-facing ones. Wind velocities are low in the foothills, increasing from there both up the mountains and down onto the plains, and with an increase in altitude there is a substantial increase in precipitation. Moderate temperatures and moisture supplies combine to make conditions in the foothill area very suitable for many organisms. The terraces, or small mesas, upon which two of my quadrats are located appear to be excellent environments for ants, and attract species from both the mountains and plains.

Armin (1963) states that the plant life of the plains zone is characterized by dry grassland with few or no trees. Pinus ponderosa, or ponderosa pine, sometimes occurs on dry bluffs where rock is exposed. The more distinctive grasses are the bunch grasses Andropogon and Sorghastrum, the wire grass Aristida, porcupine grass Stipa, the very common buffalo grass (Buchloe) and grama grass (Bouteloua). Often herbs are present, such as sunflower (Helianthus annuus), goldenrod (Solidago spp.) catnip (Mentha spicata), wild cucumber (Cucurbita foetidissima), ground mallow (Malva neglecta), horse thistle (Cirsium spp.), burdock (Anthemis cotula), ragweed (Ambrosia trifida), sage (Artemisia glauca), yucca (Yucca glauca), sand bur (Cenchrus pauciflorus), milkweed (Asclepias speciosa), prickly pear cactus (Opuntia polyacantha), mullein (Verbascum thapsus), and others. Many of these are not limited to the plains zone.

Ponderosa pine (Pinus ponderosa) is the dominant tree of the foothills zone. This tree occurs as a climax stand on gently rolling surfaces. Occasionally found between these trees are Rocky Mountain juniper (Juniperis communis), squaw currant (Ribes cereum), and grasses such as buffalo grass (Buchloe). Other dominant herbs may be Carex spp. (sedges), wild geranium (Geranium fremontii), goldaster (Chrysopsis foliosa), and mountain parsley (Harbouria trachypleura). The valley floors also have grasses and many species of herbs and sedges. Poison ivy (Rhus radicans), and sumac (Rhus glabra) are quite common in a small clearing north of the wooded quadrat. Of the grasses in my quadrats, blue grass (Poa pratensis), brome grass (Bromus brizaeformis), timothy (Phleum pratense), and cheat grass (Bromus tectorum) appeared quite prevalent.

METHODS AND MATERIALS

The boundaries of the three quadrats were marked by using wooden stakes painted at the top with red paint which were driven into the ground at ten-meter intervals on each side of the quadrats. The writer and his son then crisscrossed back and forth through each quadrat laboriously turning over rocks and logs (of which there were only a few), and, in short, did everything possible in order to locate any ant colonies, which were to be found in these quadrats. Once the ants were exposed, they were collected into 2 and 4-dram vials (depending upon the size of the ant) containing 85% ethyl alcohol, where they were killed and preserved, and a minimum of 12 ants was collected as a sample from each colony. An aspirator was tried for removing them from the nest, but it was found to be too cumbersome. Sampling of the ants from each nest was accomplished as carefully as possible so as not to unduly disturb the colony.

Into each vial was inserted a slip of paper with the date and number of colony designated, as well as the quadrat number. Later, after the vial was emptied for removal of debris, and identification of the species had been made, the ants, and a slip with the species name, were included in the vial. The vial's cap was then labelled with the quadrat and colony number. A number was painted on the stake with black paint, and the stake was driven into the ground beside the colony. Subsequent stakes were also numbered and inserted beside the nests in the sequence in which these nests were found.

In the summers of 1966 and 1967, the same procedure was followed in carefully combing each quadrat for all possible colonies located within them. In 1966, when new nests were discovered, numbered stakes in a continued sequence of numbers from those used in 1965 were also inserted beside them. Since 1967 was to be the last summer for locating colonies, stakes were not driven beside the newly discovered nests that summer. A detailed map was prepared for recording the locations of the various ant colonies for each quadrat in 1965, and in the two subsequent summers the newly discovered colonies were also included in the map (Figures 7 to 9). Figure 10 is an aerial view of the general area in which the quadrats are located, and Figure 11 shows the specific location of the three quadrats. A binocular microscope was used for identification of the various ants, and in just a very few cases a monocular compound microscope with magnification of 100x was used for a very small, precise taxonomic characteristic. Robert E. Gregg's book, The Ants of Colorado (Gregg, 1963), was used as the reference for taxonomic keys in the identification of the various species, and William S. Creighton's book, The Ants of North America (Creighton, 1950), was also utilized, especially for his outline drawings of ants.

A segment of this study was concerned with an attempt to estimate population size of the ant colonies by using the Lincoln Index which, as previously mentioned, is a mark and recapture method of census. The ants which were selected to test this method consisted of two larger species, so that marking and recognition would be facilitated. Colonies of the species Camponotus (T.) vicinus Mayr and Formica (N.) pallidefulva Latreille were utilized. Various

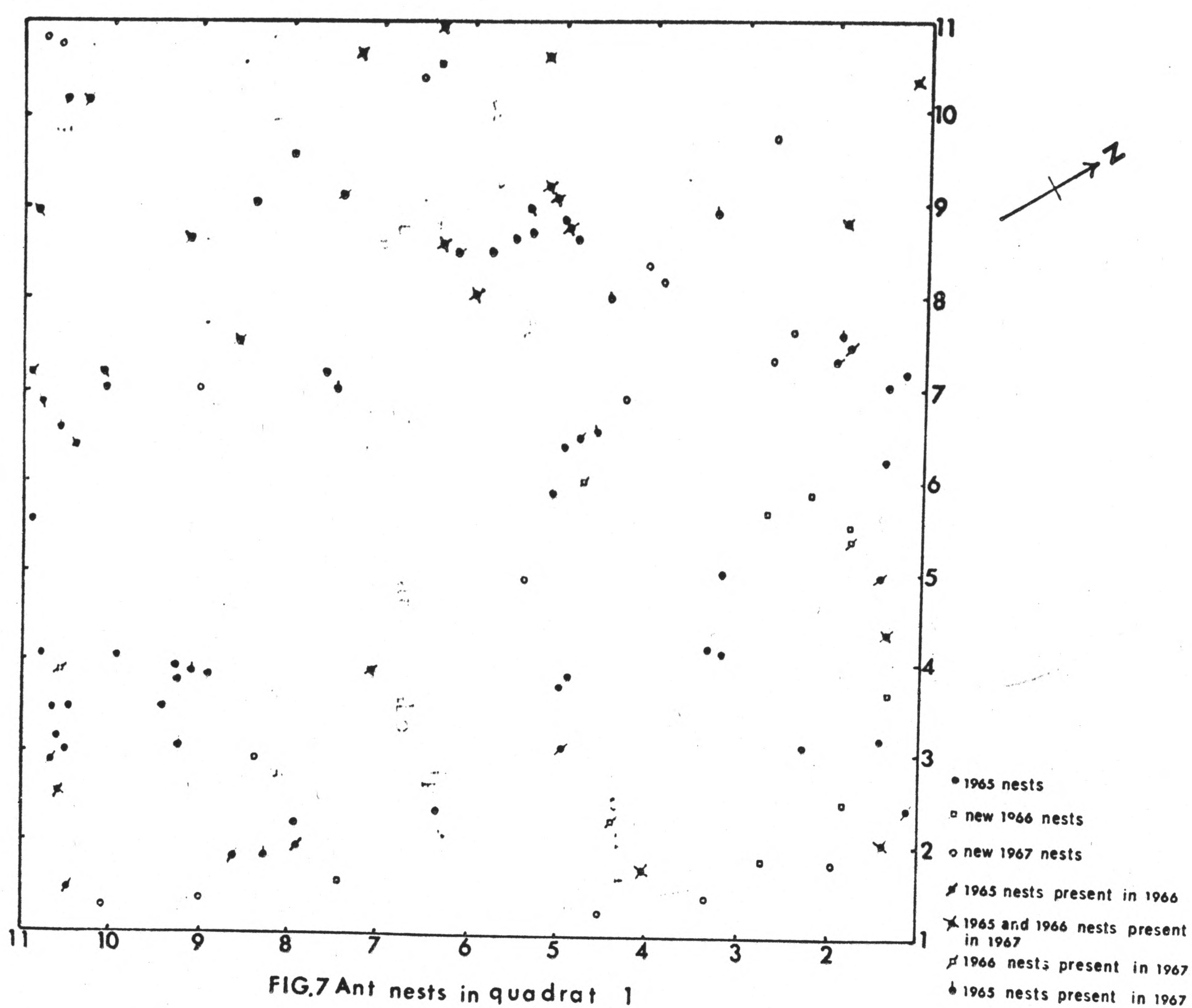

FIG.7 Ant nests in quadrat 1

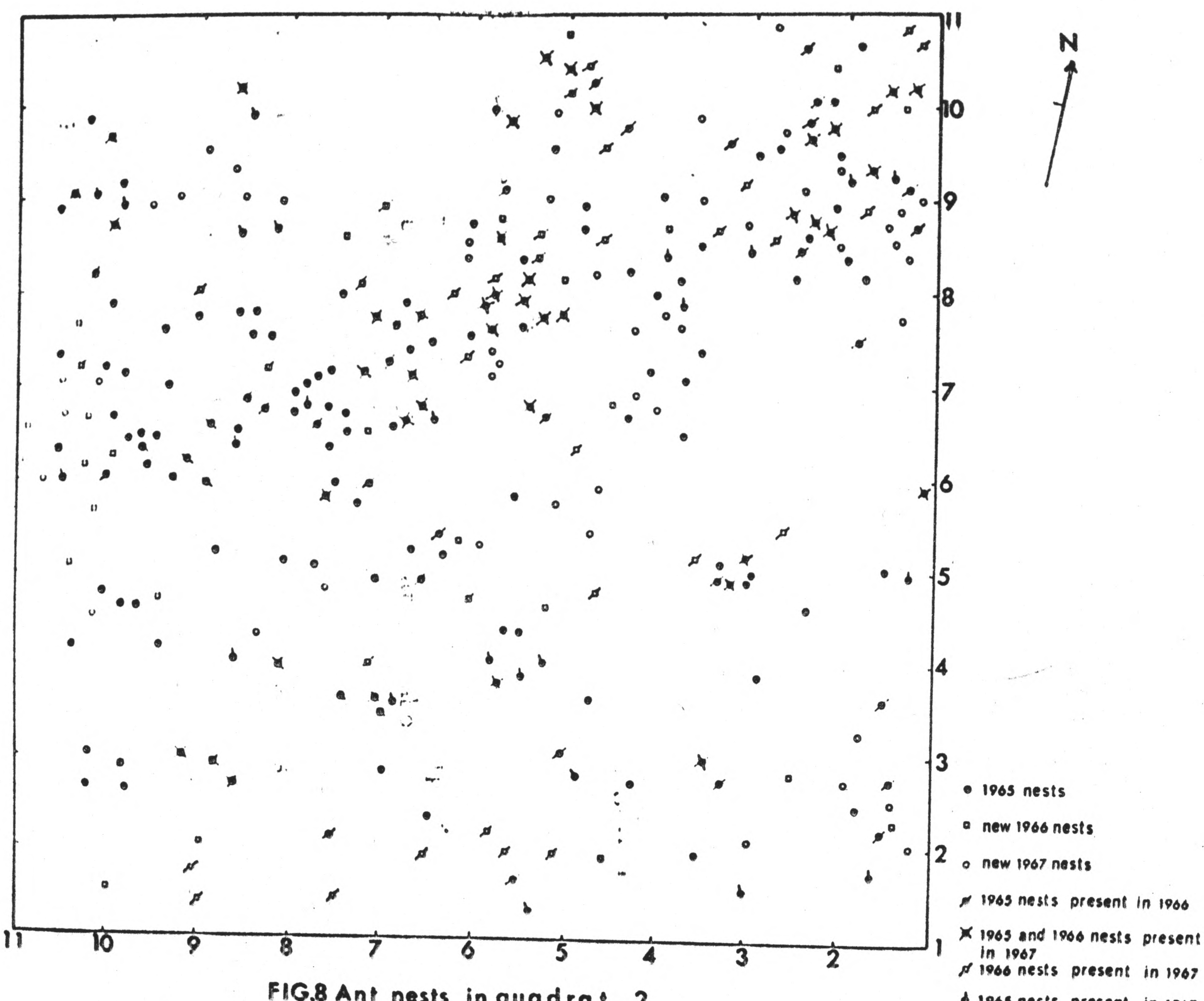

FIG.8 Ant nests in quadrat 2

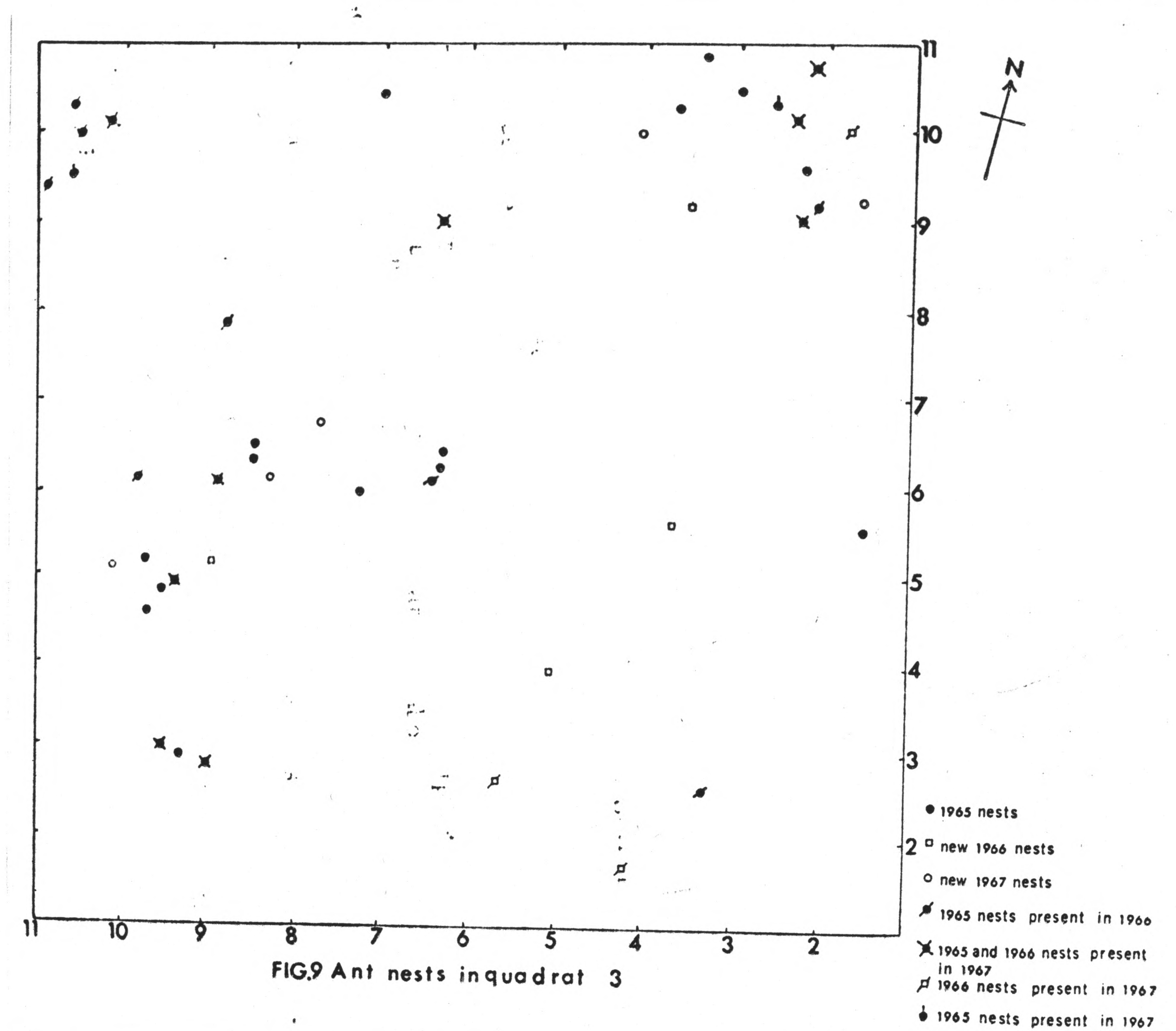

FIG.9 Ant nests inquadrat 3

Figure 10. Aerial view of plains-foothill border, southwest of Boulder, Colorado.


ECB-3-27

Figure 11. Location of Quadrats

0 .5 1 KILOMETER

CONTOUR INTERVAL 40 FEET

substances were tried, but it was found that fingernail polish was quite satisfactory for the purpose of marking. The ants which were selected for census were chosen from a location outside of the study quadrats, inasmuch as the quadrats were to be carefully examined over a period of several summers. The procedure followed in the use of the Lincoln Index method of estimation of ant colony size was very similar to that used by Chew (1959). First, 50 to 100 worker ants were collected from a colony; next, these individuals were etherized, and each ant was marked on the dorsum of the thorax with a spot of red fingernail polish; third, the marked ants were counted and then released at the colony entrance after they had revived (the few ants whose legs became bound up by the application of too much polish were removed); fourth, a second sample of ants was collected 24 hours later, and the marked and unmarked individuals were counted; finally, the total number of workers in the colony was calculated by the Lincoln Index formula. In order to determine the value of the Lincoln Index with the colonies studied, a shovel was utilized in excavating each of these nests, and every ant discovered was collected and etherized for a subsequent total count of each colony.

In 1968, the fourth summer of this project, temperatures were recorded, and soil moisture analyses were made as well. Temperatures were taken in the various quadrats three times daily, from July 29 through August 28, with a Fahrenheit telethermometer and thermistor. The latter was pushed into the soil as a probe to a depth of approximately two to three inches for subsurface temperature. The telethermometer was Model YSI, Serial No. 430, 3 scale, manufactured by the Yellow Springs, Ohio, Instrument Company. Temperatures were also taken at the surface, six inches above the ground, and about five feet above the surface. The last temperature reading is equivalent to standard meteorological temperature.

I consulted Dr. J. W. Marr, of the University of Colorado Arctic and Alpine Institute, for procedures to follow in soil moisture analysis. The materials used were a trowel, one-half-pint standard soil-sample cans, a shovel, a double-beam trip balance, and an oven. Samples of soil were placed in the one-half-pint cans, and three samples were obtained daily from each of the three quadrats. A central representative area in each quadrat was selected for soil moisture samples, as well as for temperatures. The soil samples were all taken under rocks of medium size, and included topsoil from just beneath the rock to a depth of approximately five inches. The soil was weighed to one-tenth of a gram. The cans were oven dried at 110° C. for 24 hours, and the dry weight recorded. The results were expressed as per cent moisture per dry weight soil, and were computed by the following formula:

$$\text{Soil moisture as per cent of dry weight of soil} = \frac{\text{wet weight of soil} - \text{dry weight} \times 100}{\text{dry weight of soil}}$$

At the end of the third summer (summer of 1967), after all three quadrats had been meticulously examined for new as well as old colonies (previously discovered ones), a census was begun to determine the number of adult individuals in the various nests of ants, according to the different species. It was hoped that this procedure might help indicate which of the various ant species apparently were dominants in their respective quadrat areas. This census was largely conducted in the fourth summer of research, since there was only time for the census of a few nests in the latter part of August, 1967. The census entailed excavation of each nest, and the destruction of all ants in the nest in order to make a total count. For the census of the various ant colonies, the nest was excavated and emptied into a plastic bag, and a piece of cotton saturated with ethyl acetate was inserted into the bag, which was tied with string. After the field work, the contents were removed a small portion at a time and carefully examined for ants with the use of a magnifying glass for tiny formicids. The specimens were meticulously removed one at a time with forceps, counted, and inserted into 6-dram vials filled with alcohol.

RESULTS

The results of the collection of ants from nest sites for all three years, 1965 through 1967, in all quadrats, can be seen in Tables I - IX. The research revealed 25 species and subspecies of ants over the period of these three years. Table X presents a list of these species and subspecies with information on their ranges and zonation, which has been obtained from Gregg (1963). The known range of the formicids in North America is presented to permit comparisons between the ant's overall dispersal as a species and its distribution in my research area. The altitudinal ranges are only the known limits in Colorado. The zones in which the ants occur refer only to Colorado, and these were determined by Gregg from the elevational records, the habitat types, and the geographic localities. The altitudes of life-zones in northeastern Colorado with their elevations in feet are:

Zone	Elevation in feet
Alpine	11,500 - 14,000
Subalpine	10,000 - 11,500
Montane	8,000 - 10,000
Submontane	6,000 - 8,000
Upper Sonoran	4,500 - 6,000

Distribution of the various species and the numbers of their colonies in the three quadrats can be examined in Tables XI to XIII. Table XIV provides information relative to the composition of three ant subfamilies in the three quadrats for the years 1965 to 1967.

This study attempts to focus closely on detailed aspects of ant distribution and endeavors to discover if there is any discernible boundary for ants of a sharp and narrow nature between the lower edge of the foothill zone and the plains, as there appears to be for plants. Ant species which are in the meadow and stop there, but do not penetrate the forest, and those which are at home in the ponderosa pines, but do not enter the meadow, should support the idea of an important faunal boundary. An examination of Tables XI to XIII show formicid species which do provide evidence of this boundary.

An examination of Tables XI - XIII, which are concerned with species composition for the three quadrats for 1965 through 1967, shows considerable differences in numbers of colonies for the various species for each of the three years during which ants were collected from nest sites. Since another objective of this study was to determine frequency and stability of ant colonies, examination of the tables reveals short duration and lack of permanence for numerous colonies.

The results of colony size estimation by the Lincoln Index are shown in Table XV. Four separate nests of the carpenter ant, _Camponotus_ (_T._) _vicinus_, and two nests of _Formica_ (_N._) _pallidefulva_ were used.

Another purpose of the study is to relate climate to ant distribution, and Tables XVI - XVIII present the raw data for daily temperature readings from July 29 through August 28, 1968, for morning, noon, and afternoon temperatures in each of the quadrats. To facilitate analysis of the data, Tables XIX - XXI were prepared to demonstrate weekly temperature averages in all quadrats for morning, noon, and afternoon temperatures. Tables XXII - XXIV illustrate weekly temperature maximums and minimums in all quadrats for morning, noon, and afternoon temperatures. Tables XXV - XXVIII present United States Department of Commerce, Weather Bureau records of climatological observations at Boulder. These tables include daily maximums, minimums, and temperatures taken at observation time, and point out precipitation for Boulder at the South Side Fire Station, 2225 Baseline Road, which is the Weather Bureau station nearest to my research area. Insofar as soil moisture is concerned, raw data are presented in Tables XXIX - XXXI for all three quadrats, and Table XXXII depicts the average daily and weekly per cent of moisture in all quadrats.

Another purpose of my study was to observe foraging activities of some ants. Since my son and I were more directly concerned with collection and analysis of distribution of the various species, this objective was, of necessity, a limited one; nevertheless, foraging activities were observed for four species of ants. Three of these formicids are members of the subfamily Formicinae, and one of these formicids belongs to the genus Camponotus; the other two are members of the genus Formica. The other species observed is a member of the subfamily Dolichoderinae and the genus Iridomyrmex.

I base my ideas for nest evacuation upon conditions noted in the various ant nests which might be responsible for the abandonment of the nests. Other factors which do not lend themselves to observation must also be considered, and these are noted in the discussion of this thesis.

Plesiobiosis is a name given by Wheeler (1910) to cases in which two or more colonies of different species of ants establish their nests in contiguity, or very close proximity, as often happens under the same stone. This condition was noted in 12 species, almost half of the total number of formicid species discovered in my research sites. All three subfamilies are represented by species which had compound nests, and at least one compound nest was found for each species. Of all nests examined over the entire period of the study, there were a total of 36 compound nests. Usually two species were found under the same rock in plesiobiosis, but twice there were three species discovered in the compound nest.

An attempt was made in my research to observe nests which apparently branch from the original colony. Nests of six species of ants were observed which had probably formed in this way. The subfamilies Myrmicinae and Formicinae are represented, but no Dolichoderinae ants appeared to have polydomous nests in my research area.

One of the objectives of this study was to determine the dominants among ants in the area. Like most animals in the terrestrial area, these insects are not true ecological dominants, since they do not exert a major controlling influence on the community. Therefore, they are influents at best, since formicids do not, by themselves, modify the major factoral complex of a community in such a way that other organisms can live at the same place. However, some ant species by sheer numbers or by their aggressive nature may "dominate" others.

Tables XI - XIII give the number of colonies per species in the various quadrats for all three years, and Table XIV shows composition of species by subfamily. It becomes apparent at once that the Formicinae have the greatest number of species for every quadrat and in every year; the Myrmicinae are next, and the Dolichoderinae are third. Table XXXIII represents the ant colony sizes by actual total count, which were made in 1968, a year after sampling had been completed.

One of the objectives of this study was to examine and note those ant species in the research area which apparently have nuptial flights in late summer. In 1966 and 1967 the ants were collected in August, and in both years, numerous colonies with winged specimens were observed. In 1965, the first summer of this study, collecting was accomplished in June and early July, and winged specimens were not observed. Twelve species of ants which had colonies with winged specimens were seen during the observation period. All three subfamilies of ants are represented among these 12 species.

DISCUSSION

Distribution of the Various Species

There were ten species of ants discovered in the meadow in the three years encompassed by this study, and of these ten, three species, or 30% of the total, do not penetrate the ponderosa pine forest. In fact, three other forms which do penetrate the forest do so at a very considerable reduction in the number of colonies from those found in the meadow.

The three species which do not penetrate the forest are

Lasius alienus americanus Emery
Formica obscuripes Forel
F. fusca argentea Wheeler

The two *Formica* species do not penetrate the ecotone. Of the three species, *Lasius americanus* had six colonies in the meadow in 1965, two in 1966, and one in 1967. There were five in the ecotone in 1965, three in 1966, and two in 1967. *Formica obscuripes*, found only in the meadow, had one colony in 1965, and two each in 1966 and 1967. *Formica fusca argentea* had one colony in the meadow in 1965 and none in the ecotone. From these data it would appear that the lower edge of the Transition is an actual boundary, since distributional limits are encountered for the species of ants which are in the meadow and do not penetrate the forest. For *Lasius americanus*, the termination of its distribution is sharply outlined at the lower edge of the Transition. Furthermore, the two *Formica* species help to support the idea of a terminal at the Transition Zone's lower border since they are in the meadow and do not enter the forest.

There were 20 species of ants found in the ponderosa pine forest, and of these 20, 13 species, or 65%, do not enter the meadow. Three additional species which do penetrate the meadow undergo a very considerable reduction in colony number from forest to meadow. In fact, for two of these three species only one colony was found in the meadow during the three years of this study, as compared to 24 colonies in the forest for one species and 144 in the forest for the other.

The 13 species in the ponderosa pine forest which do not enter the meadow are

<u>Lasius niger neoniger</u> Emery
<u>L. (A.) claviger coloradensis</u> Wheeler
<u>L. (C.) brevicornis microps</u> Wheeler
<u>L. niger sitkaensis</u> Pergande
<u>Formica (N.) pallidefulva</u> Latreille
<u>F. (P.) limata</u> Wheeler
<u>F. (P.) lasioides</u> Emery
<u>Camponotus (T.) vicinus</u> Mayr
<u>Crematogaster lineolata</u> (Say)
<u>Myrmica schencki emeryana</u> Forel
<u>Leptothorax rugatulus</u> Emery
<u>Iridomyrmex pruinosus analis</u> (E. André)
<u>Liometopum occidentale luctuosum</u> Wheeler

Five of the above species do not penetrate the ecotone. These are

<u>Lasius (C.) brevicornis microps</u> Wheeler
<u>L. niger sitkaensis</u> Pergande
<u>Formica (P.) limata</u> Wheeler
<u>Leptothorax rugatulus</u> Emery
<u>Liometopum occidentale luctuosum</u> Wheeler

In an analysis of the eight species in the forest which penetrate the ecotone but do not enter the meadow, it may be seen that <u>Lasius niger neoniger</u> had 44 colonies in the forest in 1965, 30 in

1966, and 29 in 1967, but in the ecotone there were only two of this species in 1965, one in 1966, and none in 1967. Lasius claviger coloradensis had one colony in the ecotone in 1965 and none in the other two years; however, there was one colony in the forest in 1967, but none had moved into the meadow. The formicid, Formica (N.) pallidefulva, in the ecotone had 32 colonies in 1965, 22 in 1966, and 21 in 1967; and there were six in the forest in 1965, four in 1966, and six in 1967. In spite of the considerable number of nests of this species in the ecotone, none were ever discovered in the meadow. This would appear to be further evidence for a faunal distributional border between the lower edge of the foothill zone and the plains. Insofar as Formica (P.) lasioides is concerned, the forest had one colony in each of the three years, and the ecotone had one in 1966 and 1967, but two in 1965; however, no colonies were found in the meadow. Camponotus (T.) vicinus was represented in the forest by 15 colonies in 1965, 16 in 1966, and nine in 1967, but in the ecotone there were eight in 1965, and nine each in 1966 and 1967. Further evidence can be seen here of a distributional limit between the lower edge of the foothill zone and the plains, since no vicinus colonies whatsoever were located in the meadow. In 1965, six colonies of Crematogaster lineolata were found in the forest. One of these was located in 1966, and five in 1967; however, only one was discovered in the ecotone, and this was in 1967, but none of these ants moved into the meadow. Myrmica schencki emeryana had one colony in the forest in 1967, one in the ecotone in 1965, and three colonies in 1966, but the meadow did not have any nests of emeryana at any time. There was one colony of Iridomyrmex pruinosus analis in the forest in 1967, and in the ecotone there were two colonies each in 1965 and 1966, and one in 1967; however, none was found in the meadow.

In the above descriptions, since in some cases the nests were located at the same places in all of the three years, we can probably assume that the same colonies were present. However, there appeared to be considerable instability of the nests in the study areas, and in spite of this lack of permanence, no ants of the above species migrated into the meadow from the lower edge of the foothill zone. Although of no importance insofar as evidence of a faunal boundary is concerned, it is of interest to note that there were two species confined to the ecotone. These illustrate one of the principles of ecology, whereby organisms are often found which are characteristic of, and often restricted to, the ecotone. In any event, these ants increase the faunal wealth of the region, and these two species are

Formica obscuriventris clivia Creighton
Pheidole pilifera coloradensis Emery

From the information gleaned from the three quadrats relative to the ant species which do not enter the meadow from the forest and those which do not penetrate the forest from the meadow, it would appear that an important boundary exists for ants between the plains and foothills, which thus parallels the more conspicuous vegetational changes.

Of the three subfamilies represented by the species in my research areas, the Myrmicinae had six, or 24% of the total number of species, and these six species were also in six different genera.

These genera are

Crematogaster
Myrmica
Aphaenogaster
Solenopsis
Leptothorax
Pheidole

Of these six Myrmicine species, two were in only one quadrat (22.2% of the total number of single-quadrat species represented), two were in two quadrats (18.2% of all two-quadrat species), and two were in all quadrats (40% of the three-quadrat species).

The Formicinae were represented by three genera with 16 species which represents 64% of the total number of species discovered. One of the genera, *Formica*, had four species confined to one quadrat (44.4% of the total number of single-quadrat species), and four species found in two quadrats (36.4% of all the two-quadrat species). Another genus of the Formicinae, *Lasius*, had two species found in only one quadrat (22.2% of all single-quadrat species), three two-quadrat species (27.3% of all two-quadrat species), and two three-quadrat species (40% of the total number of three-quadrat species). The third genus of the Formicinae, *Camponotus*, had one two-quadrat species (9.1% of the total number of two-quadrat species).

The Dolichoderinae, or third sub-family, had three genera with three species (one species per genus). These three genera are *Iridomyrmex* with one two-quadrat species (9.1% of all two-quadrat species), *Liometopum* with one single-quadrat species (11.1% of all single-quadrat species), and *Tapinoma* with one three-quadrat species (20% of all three-quadrat species). Obviously, species found in all quadrats would be very tolerant ones and therefore widely distributed, with single-quadrat and species found in two quadrats progressively less adaptive, as well as having a much narrower distribution. In this study, two-quadrat species form the largest group with a total of 11; however, this group is followed very closely by the single-quadrat group with nine species.

It is of interest, further, to note that of the Myrmicinae and Formicinae, the former are twice as numerous in genera as the latter. In the three-quadrat group, there are the same number of myrmicine species as formicine species, but in the two-quadrat group, there are eight formicine species to only two of the myrmicine species, or four times as many two-quadrat formicine species. These findings confirm Gregg's similar observations in his The Ants of Colorado (1963) for the Formicinae and Myrmicinae, and perhaps, as Gregg suggests, The Formicinae are more advanced and geographically and ecologically more adjustable. In any case, this situation does appear to parallel evolutionary advance, as suggested by Gregg.

Gregg (1963) draws up lists of ants which, he writes, demonstrate the existence of a faunal boundary in the area of the Transition Zone. Only those ants which penetrate the Transition from the Sonoran or the Canadian, and whose upper and lower limits are determined by that zone, are included in the lists. He found 45 ants with their upper distributional limits somewhere in the Transition Zone, and 17 ants with their lower limits in the Transition, and from this information he was able to establish that the submontane is a boundary, or meeting place, between northern types of ants and those from southern sources and thus coincides with the vegetation pattern.

My study does not contradict the conclusion reached by Gregg relative to the existence of the boundary in the area of the

Transition Zone. Gregg's study was made on a state-wide basis with records from all over Colorado, whereas my research is concerned with the lower edge of the Transition Zone in a very limited area in which the quadrats were selected near to each other in different kinds of vegetation. My study thus is more closely focused on the minutiae of distribution in an attempt to discover if there is actually a discernible boundary of a sharper and narrower nature than the distributional terminal described in Gregg's book.

Stability and Frequency of Colonies

The classification of the 25 species and subspecies of ants found in my research is as follows:

Family Formicidae

- Subfamily Myrmicinae
  - Genera and Species
    - *Crematogaster* Lund
      - *Crematogaster lineolata* (Say)
    - *Myrmica* Latreille
      - *Myrmica schencki emeryana* Forel
    - *Aphaenogaster* Mayr
      - *Aphaenogaster (A.) subterranea valida* Wheeler
    - *Solenopsis* Westwood
      - *Solenopsis (D.) molesta validiuscula* Emery
    - *Leptothorax* Mayr
      - *Leptothorax rugatulus* Emery
    - *Pheidole* Westwood
      - *Pheidole pilifera coloradensis* Emery

- Subfamily Formicinae
  - Genera and Species
    - *Camponotus* Mayr
      - *Camponotus (T.) vicinus* Mayr
    - *Lasius* Fabricius
      - *Lasius alienus americanus* Emery
      - *Lasius niger neoniger* Emery
      - *Lasius niger sitkaensis* Pergande
      - Subgenus *Chthonolasius*
        - *Lasius (C.) brevicornis microps* Wheeler
        - *Lasius (C.) umbratus aphidicola* (Walsh)

Subgenus _Acanthamyops_
Lasius (A.) claviger coloradensis Wheeler
Lasius (A.) latipes (Walsh)
Formica Linnaeus
Subgenus _Proformica_
Formica (P.) lasioides Emery
Formica (P.) limata Wheeler
Subgenus _Neoformica_
Formica (N.) pallidefulva Latreille
Formica (N.) pallidefulva nitidiventris Emery
Subgenus _Formica_
Fusca group
Formica fusca Linnaeus
Formica fusca argentea Wheeler
Rufa group
Formica obscuripes Forel
Formica obscuriventris clivia Creighton

Subfamily Dolichoderinae
Genera and Species
Iridomyrmex Mayr
Iridomyrmex pruinosus analis (E. André)
Liometopum Mayr
Liometopum occidentale luctuosum Wheeler
Tapinoma Förster
Tapinoma sessile (Say)

In the following descriptions and characteristics of the various species which were discovered in my quadrats, much of the material used has been obtained from Gregg (1963) and Creighton (1950). In describing the frequency of ants, I used Gregg's (1963) classification of abundance of ants in Colorado. This classification is based upon four categories, and placement in these categories depends upon the number of records. These categories are

Abundant	(over 100)	Frequent
Common	(50-100)	
Uncommon	(10-50)	Infrequent
Rare	(1-10)	

The subfamily Myrmicinae surpasses all other groups of ants in the extent of variation in morphology and habits. As has been noted, six species of this subfamily were represented in my quadrats, and their descriptions follow.

Crematogaster lineolata (Say) has a range which extends from eastern Canada through the North Atlantic States and North Central States to eastern Colorado, a southern extension follows the Appalachian Highlands to northern Georgia. This ant is very widespread in the northern and eastern United States stretching as far west as Colorado. Its subspecies emeryana replaces it here, and the two probably intergrade. Most species of Crematogaster nest under stones, in logs, or in standing timber, and many tend aphis and build carton sheds over them. Similar carton containers are often made by lineolata and used as brood chambers, and such incubators may be several yards away from the main nest; however, these carton brood chambers are abandoned at the beginning of the fall.

This species is considered to be rare in Colorado, for Gregg lists two records as of 1963. In my research, Crematogaster lineolata was not found in the meadow at any time, nor, for that matter, in the ecotone during 1965 and 1966; however, one nest was located there in 1967. In the wooded region, in 1965, this investigator discovered six colonies, one of which was present all three years, and was the only one found in 1966. In 1967, five nests were observed and sampled. From the above data, it can be concluded that lineolata is unstable in its nesting habits, and can also certainly be considered an infrequent species.

Myrmica schencki emeryana Forel has its range in Newfoundland to Georgia and west to the Rocky Mountains. As of 1963 there were 38 records of this species, which classified it as uncommon. This myrmicid is a subspecies under the European species _schencki_. It and other members of the genus _Myrmica_ prefer to nest in the soil, and often use a covering object above the nest. As a rule, they are inoffensive ants. The distribution of _Myrmica_ is most interesting, as it is the only large Holarctic genus which lacks xerophilous or subtropical representatives on this continent. A map showing the distribution of _Myrmica_ in North America would show a widespread occurrence in Canada, with northern limits reaching Labrador in the east and Alaska in the west. Proceeding southward, one does not find it restricted to areas of moderate to considerable elevation in both eastern and western United States as it is now known from sea level. In the western mountains, the genus is abundant in subalpine and Canadian zones, in decreasing numbers in the Transition Zone and absent in Sonoran areas.

In my study none was found in the meadow, but some were discovered in the wooded area and in the ecotone. Although my research revealed few colonies of _Myrmica schencki emeryana_, more were found in the ecotone than in the other two quadrats. In the ecotone in 1965, only one was recorded, but in 1966 there were three, one of which was probably the same nest as in 1965, since it was at the same site. Only one nest was discovered in the forest, and that was in 1967, but no colonies were ever found in the meadow. This ant must obviously be considered infrequent. Although the data for this insect are meager, it would appear that Myrmica emeryana is inherently unstable in its nest habits, since it apparently changes nest sites frequently.

The range of Aphaenogaster (A.) subterranea valida Wheeler is the Rocky Mountain region from southern Colorado north to British Columbia and west to the mountains of Utah. Gregg (1963) lists 72 records, and therefore, classifies valida as common. This subspecies is common in northern and central Colorado, but appears to diminish in southern Colorado. It holds sharply to the Transition Zone; it is absent from every zone both above and below this one. Aphaenogaster valida is a Rocky Mountain form of the species subterranea, and appears to nest under stones in moist, shady foothill canyons, although Creighton (1950) writes that it nest in dry and fully exposed situations. This investigator found, by far, the vast majority of records in the woodland, a fact which supports an observation of Gregg's, in that more ant records are found in forests.

In my research area, Aphaenogaster valida was an abundant ant, especially in the wooded unit, for in that quadrat, 52 nests were discovered in 1965, 48 in 1966, and 44 in 1967. Of those 52 nests located in 1965, only ten continued throughout the three years (18% stability); however, 12 others persisted into 1966 but no longer. It is perhaps of interest that in 1966 there were 23 new nests, of which 13 were also present in 1967 (57% stability for the period 1966-1967), and, in addition, there were 13 new nests in 1967. In 1965, I discovered eight colonies in the ecotone, two of which persevered throughout the study period, and two others extended as far as 1966 but not into 1967. In 1966, the ecotone yielded six nests, two of which were new, and the same number (six) was present in 1967, one of which was new; however, in the meadow, only one colony was discovered, and that was in 1966. From the above information, it appears that *Aphaenogaster valida* is quite stable.

The range of *Solenopsis (D.) molesta validiuscula* Emery is Pacific Coast states eastward to Idaho, Colorado, and New Mexico. There were 56 records in Colorado in 1963, and occurrence is, therefore, common. This tiny, brownish-yellow ant is the common western form of *Solenopsis molesta*. It is quite common in the lower foothill zone, although it is rather abundant at various places on the plains and other Sonoran habitats. This species reaches higher elevations than *molesta*, the Eastern species, and Gregg (1963) believes it replaces *molesta* in mountainous western United States.

These insects, as well as some of their relatives, are known to be thief ants (lestobiosis). Their colonies are usually founded in close proximity to the nest passages of some larger species with which the tiny passages from the nest of the thief ant communicate. A steady pilfering of brood or other food from the nest of the larger species is carried on in such obscurity that the larger species rarely seems aware of its loss. These thief ants only occasionally forage above ground, and are almost impossible to see when they do so because of their minute size. Their stings are so small (few individuals exceed 2 millimeters in length) they have no effect on human skin, although they are very bad-tempered and pugnacious.

Solenopsis (D.) molesta validiuscula Emery was ubiquitous, insofar as habitations in all three quadrats is concerned, although not as abundant as some species such as Aphaenogaster (A.) subterranea valida Wheeler. In the ecotone in 1965 seven sites were recorded, none of which was present in 1966; however, three of the same sites were occupied by Solenopsis validiuscula in 1967. The year 1966 yielded only one nest in the ecotone; 1967, on the other hand, yielded ten colonies in that quadrat. In the wooded region in 1965 two sites were occupied by Solenopsis validiuscula; in 1966 none were present; but in 1967 five were established. In the meadow 1965 and 1966 yielded eight colonies each, one of which persisted through to 1967; three others were existent in 1965 and 1966, but did not continue into 1967, and three colonies were found in the meadow in 1967. It would seem that Solenopsis validiuscula's nest stability rates are low.

Leptothorax rugatulus Emery has the following range: Rocky Mountains, Sierra Nevada and Cascade Ranges, mountains of Arizona and Utah, and an eastern extension into the Black Hills of South Dakota. Gregg (1963) classified its occurrence as uncommon with 31 records. Creighton (1950) writes that Leptothorax rugatulus is widely distributed in the Transition Zone of the Rocky Mountains. Gregg (1963) found one site as high as 8700 feet in elevation in southwestern Colorado. The population in the California Sierras averages darker than that in the Rockies, but the full color range is present in both areas. This species shows many slight variations in sculpture, but thoracic rugae are always present.

Leptothorax rugatulus Emery was never located in the ecotone and meadow, but in 1965 the wooded quadrat yielded six nests, none of which were present in 1966; however, the latter year saw five new records established in the forest. 1967 was the most abundant year, for 12 colonies were discovered, and two of these 12 colonies had persisted from 1966. From the above, it appears that rugatulus has very unstable nesting habits.

The last one of the six species of the subfamily Myrmicinae discovered in my study area is Pheidole pilifera coloradensis Emery which has the following range: northern New Mexico through Colorado to the Dakotas. Gregg (1963) indicates 53 records with a consequent common occurrence for this insect; however, it is not considered a truly common ant in the total fauna of Colorado. It is found in both the Upper Sonoran and the Transition Zones, and is, therefore, a generally more tolerant ant than most of the other species of its genus. Pheidole pilifera coloradensis Emery is host to the parasitic ant Epipheidole inquilina Wheeler, and Gregg, at the writing of his book, The Ants of Colorado, had not discovered any individuals of the parasite. I am sorry to say that I had no better fortune than Dr. Gregg in finding inquilina.

Seeds have been found in nests of Pheidole coloradensis, and two species of plants have been recognized; Erysimum sp. (wallflower) and Chenopodium leptophyllum (narrowleaf goosefoot). Most of the species garner seeds, and it is believed that the large-headed major workers function as seed huskers. Since the enlarged head of the major is mainly filled with mandibular muscles, this enables the jaws to exert considerable pressure, which should be useful in cracking off the husks of seeds; however, the ant will accept other food as well as seeds, such as animal tissue.

The colonies are usually small; however, they are generally larger than those of the typical eastern pilifera. Pheidole coloradensis nests in the soil, and prefers to nest in canyon bottoms and along the banks of streams. Browne (1958) and Byars (1936) found this thermophilic ant mainly on warm dry slopes, and Smith (1962) found it on the sunny slopes of both sides of Valmont Butte. Its nest may be built under a stone or in open soil without a covering object, but when no cover is present, there is often a mound or crater of excavated soil around the nest entrance. In Colorado Pheidole coloradensis is most often found at elevations between 5000 and 6000 feet, and is more abundant on the eastern slopes of the Rockies than to the west of them.

This insect was rare in my study, and was never discovered in the forest or meadow. In the ecotone one nest was located in 1965 which disappeared by 1966; however, another colony was recorded in 1966 which persisted until 1967. In the latter year only that one colony which continued from 1966 was present. On the basis of this meager evidence, it is difficult to assess this formicid's stability.

In the subfamily Formicinae the structure of the genera is not strongly variable, but the habits of the ants in the subfamily are highly diverse. As outlined in the classification, three genera with a total of 16 species were found in the quadrats.

Camponotus (T.) vicinus Mayr has its range as follows: South Dakota to Oklahoma and west through the Rocky Mountains to the Pacific Coast from British Columbia south into the highlands of Mexico, and Gregg lists 166 records as of 1963 with its occurrence as abundant. This frequent formicid is represented in a broad selection of plant communities, and occurs in a great variety of geographic localities. It inhabits numerous vegetation types, both open and wooded, but it is almost never found in dense forest. It prefers clay soil, and in almost all instances, its nests are found beneath rocks, but occasionally the nests are found under boulders, and it is exceptional to find Camponotus vicinus in decaying logs. It is usually an inhabitant of high plains, mesas, and mountain foothills, and appears to avoid the hottest, lowest, and most arid of the desert regions.

This formicid was not located in the meadow at any time. In the ecotone there was great stability of colonies of this ant, since of the eight sites at which Camponotus vicinus was discovered, in 1965, all were perpetuated throughout the three years, and in 1966 and 1967, a new colony was added for each year providing the ecotone, therefore, with nine colonies in each of those two years. The forest held 15 nests in 1965, of which only two were maintained throughout the research period, and the same quadrat provided 16 colonies in 1966; seven of these continued into 1967. There were nine colonies in the wooded region in 1967, only two of these were new nests previously not established. It would seem that, in general, although stability of this ant is not at a consistently high rate, in comparison with some other species, Camponotus vicinus is apparently quite stable.

Of the genus Lasius Fabricius, Creighton (1950) writes

"As far as is known, all our species of Lasius tend root coccids and aphids. In the case of the strongly hypogaeic species of Chthonolasius it is thought that these insects subsist mainly on the secretions of the coccids and aphids. Other species, particularly our two representatives of the subgenus *Lasius*, are more active in foraging above ground and supplement this diet with various foods. Most of the species of *Lasius* are remarkably flexible as to the types of nest sites which they will utilize, although most of them appear to prefer well drained soil that is not too dry. The nests may be free in the soil, under stones or other covering objects or in and under rotten logs and stumps."

The range of *Lasius alienus americanus* Emery is southern Canada and all of the United States except southern Florida, Texas, and arid sections of the Southwest. Wilson (1955) regarded it as holarctic in distribution, and Creighton writes of its higher incidence in the East and Central States than in the West. There were, up to 1963, 148 records of this ant in Colorado, which classifies it as abundant. The distribution of this formicid is wide, since it is found in all the life zones in Colorado except the Alpine; it does, however, extend to over 10,000 feet in elevation. Gregg's records from the Upper Sonoran Zone predominate, with those from the Transition a very close second.

Ecologically, *Lasius americanus* tolerates a wide variety of habitats and microhabitats, but Gregg never found any in rotting logs, although this type of nest site is often used in the Eastern and Midwestern states. None of my records were found in rotting logs either. The moisture requirements of this ant probably force it to depend on supplies of water in the soil under moisture-conserving objects, such as stones. Smith (1962) writes that though this ant is often found building small craters in grassy areas, colonies were found only under rocks in the Valmont area. I also found this ant only under rocks in my region.

Insofar as my research study is concerned, Lasius alienus americanus Emery was not present at all in the forest in any of the three years of this study. In 1965 in the ecotone there were five colonies, none of which extended through 1966 and into 1967; however, two of these five colonies persisted into 1966, and three nests were located in 1966. In 1967, there were two nests, one of which was also at the same location in 1965, but no ants were discovered there in 1966. Six Lasius americanus colonies were found in the meadow in 1965, and none of these persevered into 1966 and 1967; however, one did continue into 1966. In the year 1966 the meadow yielded two colonies, whereas in 1967 the meadow offered only one. These records would seem, therefore, to indicate that Lasius americanus shows little nest stability.

Lasius niger neoniger Emery has the following range: southern Canada and eastern United States, except Florida and the Gulf Coast, west to the Rocky Mountains. Gregg classifies this ant as abundant in Colorado with 133 records by 1963. Mrs. R. Gregg, according to Gregg (1963), showed that neoniger's habitat preferences are in open and especially sandy areas, and it nests in the soil or under covering objects (sticks, rocks, and so forth). Its common competitor is Lasius alienus americanus Emery. An open substratum free of the accumulation of organic debris is also believed to favor the occurrence of neoniger, and is a limiting factor in its distribution. Wilson (1955) emphasizes that this species has most of its nests in exposed locations such as fields, meadows, grassy roadsides, trails, and sandy blowouts. Gregg writes that this is especially true of the East, but that in the western states, neoniger is often found in forests and areas other than those cited by Wilson. This is certainly borne out by my study, since I have by far a large majority of species in the wooded region.

Gregg found one case in which neoniger was about to become host to Lasius (A.) murphyi Forel. A deälated female of the latter species was seen entering a neoniger nest under a piece of dung. Solenopsis (D.) salina Wheeler was taken on a different occasion in a lestobiotic relationship (presumably) with neoniger. Wheeler (1917) gives a very complete account of the manner in which the female of subumbratus behaves as a temporary social parasite when founding its colony in the host nest of neoniger. The intruding female at first attempts to make "friends" with the neoniger workers, but is usually repulsed by them. The neoniger workers may seize the appendages of the intruder, but they do not press the attack and soon release her. The subumbratus female then hides in the neoniger nest, and appropriates a part of the brood, over which she crouches until she has secured the neoniger nest odor. She is, thereafter, accepted without any further trouble by the neoniger workers. Nothing definite is known as to what becomes of the neoniger queen, but it seems certain that she is eliminated, probably by the intruding female.

Lasius niger neoniger Emery was common in my research area, especially in the wooded area, but it was never found in the meadow. In 1965 at the ecotone two sites revealed this species of ant, and the year 1966 produced only one colony, and this one was at a new nest site, but no colony was discovered in 1967 at the ecotone. The wooded quadrat was a very favorable area for neoniger, since 44 nests were located in 1965, and of this total, ten persevered throughout the duration of this project (23% stability). Another five were on hand both in 1965 and 1966, but had disappeared in 1967. In the second year of this study (1966) 30 colonies were located, ten, as previously mentioned, were stable throughout the research, nine others which were newly discovered in 1966 were also located at the same sites in 1967. In 1967 29 nests were recorded, six of these were entirely new. This formicid appears to have considerable nest stability, at least more so than some of the other species discovered in this study.

The range of my next species, _Lasius niger sitkaensis_ Pergande, is transcontinental; it extends from Nova Scotia across the northern United States and southern Canada to the Pacific Coast, north to southern Alaska, and south through the Rocky Mountains, Great Basin, the mountains of California, and an isolated population in the Black Mountains, North Carolina. It is classified as abundant in Colorado with 164 records by 1963. This formicid is a geographical race of _Lasius niger_ Mayr, and is primarily a western and moderately boreal form; however, the other race--_neoniger_ is an eastern form which extends quite far south. Colorado, in the midst of their overlap, has an abundance of each subspecies and a wealth of intergrades as well. This ant is much more abundant in higher elevations and in boreal vegetation types than is _neoniger_. This investigator collected a much larger number of species of _neoniger_ than _sitkaensis_. Gregg has one record of it serving as host to _Lasius (C.) subumbratus_ Viereck, one record of a nest containing larvae of the syrphid fly _Microdon_, and one case in which the thief ant Solenopsis (D.) truncorum Forel was found inhabiting the walls of a Lasius nest, but in no case did I find any association between Lasius sitkaensis and any other ant. Creighton does not believe sitkaensis is a northern race and neoniger a southern one, but Gregg's data certainly support the contention that both are geographical races. They are connected by innumerable intermediate stages or intergrades and their ranges overlap widely.

There were no colonies of Lasius niger sitkaensis Pergande in the ecotone and meadow for any of the three years spanned by this research. In 1965 the forest relinquished four colonies, one of which was present all three years (25% stability). In 1966 four nests were found, none of which, with exception of the station recorded in 1965, persisted into 1967. The forest relinquished two colonies in 1967, one of which was at a completely new site. This formicid apparently shows considerable instability in its nesting habits.

My next two species of Lasius ants belong to the subgenus Cthonolasius. The first one, Lasius (C.) brevicornis microps Wheeler had 11 records by 1963, and was, of course, considered uncommon. Its range is Alberta south to Colorado and westward into California. Lasius (C.) brevicornis Emery is primarily an eastern species, but it does reach into the Rocky Mountains. Some western specimens appear to depart somewhat from the typical eastern form, and perhaps are intergrades between brevicornis and its subspecies microps, and Colorado is probably an area of extensive interbreeding. This formicid is represented in moist forests, but can also penetrate into warm and dry situations, of which it is more tolerant than the typical brevicornis. However, in my research, all of the records were established in the wooded area. It regularly takes advantage of nesting sites which save moisture and enable the ant to escape the direct effects of hot, dry weather.

Lasius (C.) brevicornis microps Wheeler had no stations in the ecotone or meadow in any of the three years encompassed by this study; however, in 1965 the forest provided this investigator with samples from 25 colonies. Nine of these colonies continued on through 1967 for a stability of 32%, and there were 21 colonies in 1966 including those discovered in 1965. Four of the 21 were also present in 1965, but were not existent in 1967. In 1967 a total of 22 nests were located, which figure, of course, includes the original nine from 1965. Five of the colonies located in 1967 had been discovered in 1966 and persisted to 1967. Although this species does appear to carry through from one year to the next in a number of cases, in general, it is a valid conclusion that the majority of the nests of Lasius microps lacked stability.

The other species of Lasius belonging to the subgenus Chthonolasius is Lasius (C.) umbratus aphidicola (Walsh). This formicid has the following range Nova Scotia and New Brunswick south to the Gulf States, and westward through the United States to the Rocky Mountains. Its occurrence is classified as uncommon in Colorado, since there were 16 records as of 1963. This ant generally prefers fairly moist and cool situations, nesting along the borders of woods, near streams, in moist meadow soil, and very often under stones where moisture is conserved. In eastern woodlands, it can be seen in rotting logs, but Gregg (1963) writes that although in

Colorado it has not been seen in rotting logs, this may be due to the rather small number of records, and this investigator did not find any in rotting logs either. Gregg, on one occasion, found Leptothorax rugatulus Emery associated with this species in what was at least a plesiobiotic relationship.

In the ecotone during 1965 six nests of Lasius (C.) umbratus aphidicola (Walsh) were discovered, only one of which was also occupied in 1966 and 1967 (17% stability); 1966 offered only that one nest, and 1967 only one other in addition. In the wooded quadrat three nests were located in 1965, one of which was at the same site all three summers (33% stability). In 1966 two additional nests were found, and in 1967 six sites were occupied, one of which was the nest present all three years. The meadow had the largest number, since in 1965 there were 12 records; however, only two remained all three years (17% stability); two others persisted until 1966. There were six nests in 1966 and eight in 1967. From the above, it would appear that Lasius aphidicola is weak in nest stability.

The last two species of Lasius in my research area are both in the subgenus Acanthomyops. Without exception, the ants in this subgenus lead a largely subterranean existence, since the nests are often built under stones or logs, or at the base of old stumps, and infrequently, they are built in the soil with no covering object. During the marriage flight the workers come out of the nest in large numbers, but this is the only time when they are easy to find above ground, for most of the time they are underground tending root aphids and coccids. All Acanthomoyops species have a characteristic odor of lemon verbena, which Wheeler considers to be nest odor, but Creighton believes it is only produced when the ants are disturbed, and is more of a repugnatorial device. Because of the peculiar structure of the females of some of the species, it is generally assumed that these species, and probably others as well, are temporary social parasites.

The first of the two _Acanthomyops_ species in my quadrats is _Lasius_ _(A.)_ _claviger_ _coloradensis_ Wheeler. Its range is Colorado and northern New Mexico, and since there were ten Colorado records by 1963, it was classified as rare in occurrence. This ant is a subspecies of _Lasius_ _(A.)_ _claviger_ (Roger), which is an eastern and midwestern species, and _Lasius_ _claviger_ is seldom found here, probably due to insufficient moisture. It overlaps with _Lasius_ _coloradensis_ in Colorado, but _coloradensis_ is more tolerant of drier habitats, although it will nest in moist sites when these are available. Creighton (1950) writes that the nests of _coloradensis_ are often located on open intermountain plateaus where the only cover is that furnished by sage-brush bushes.

Lasius _(A.)_ _claviger_ _coloradensis_ Wheeler was found in the ecotone in 1965 at one site, but not again in 1966 or 1967. One nest was discovered in the forest, but only in 1967, and no nest was located in the meadow. There is too little information available here to comment on nest stability for this species.

The other _Acanthomyops_ species in my study is _Lasius_ _(A.)_ _latipes_ (Walsh). The range of this insect is coast to coast in the northern United States with southern extensions to South Carolina, in the Rocky Mountains to New Mexico, to the Sierras in California, and north to Alaska. There were 41 records by 1963, and it, therefore, is considered uncommon. This species is the most successful species of the Acanthomyops group in Colorado, judging by the abundance of locations, from which Gregg has reported it. It is tolerant of widely ecological conditions which probably accounts for its broad dispersal, and it often invades rather dry situations, where it is usually found under large rocks or boulders. This formicid is a temporary social parasite on Lasius (subgenus Lasius), and Gregg found one case in which a mixed colony consisted of Lasius latipes and its host Lasius alienus americanus Emery. A case of probable plesiobiosis was discovered between latipes and Myrmica sabuleti americana Weber, and Solenopsis (D.) molesta validiuscula Emery was also present under the same boulder. Gregg observed a nuptial flight of latipes after a shower at 5 P.M. on August 6, 1955; it is noteworthy that most of Gregg's records for reproductives of this species are also in August.

Lasius (A.) latipes (Walsh) was not located in the ecotone until 1967, and then, only at one site which had been occupied by Lasius alienus americanus Emery in 1966. The wooded region yielded four colonies in 1965, only one of which persevered for all three years. In 1966 this particular colony was the only one present, and in 1967 there was one other besides the nest which persisted for the duration of this study. Twenty-five per cent stability was apparent here for the wooded quadrat. In the meadow in 1965 three nests were discovered none of which were located again, but two were noted in 1966, one of which was also present in 1967. In fact, in 1967 that single nest was the only one recorded. This species was obviously rare in my study, and also had poor nest stability.

In the genus Formica eight species of ants were discovered. This genus has many outstanding characteristics. It is the largest genus of ants in America north of Mexico, and its members make up about one-sixth of the entire ant fauna. A very large number of forms in this genus are endemic to the United States and Canada. Behavior is also quite variable in this genus, for there is slave-making, various kinds of temporary social parasitism, and several distinct types of nest construction. Also, this genus affords excellent opportunity for zoogeographical studies.

The eight species of ants which were recorded from my study plots are in three subgenera, one of which is the subgenus Proformica. Two of the three species in this subgenus were discovered. Each of the three has nesting habits identical to the other two. The colonies are generally small, and the nests are usually constructed in soil beneath stones or other covering objects. Often these ants are regarded as timid, because they are preyed upon by species of the sanguinea group, but they do not lack in pugnacity and will defend their nest if disturbed. It is probably because of their small size, rather than their lack of courage, which makes it possible for sanguinea species to enslave them.

One of the two species of Proformica discovered in my research is Formica (P.) lasioides Emery. Its range is as follows: coast to coast in southern Canada and northern United States with a southern extension into the mountains of California, in the Rocky Mountains to New Mexico, and in the Appalachian Highlands.

The occurrence is common in Colorado, since 79 records were established by 1963. This ant is a slave ant for _Formica_ (_R._) _wheeleri_ Creighton.

Formica (_P._) _lasioides_ Emery was never found in the meadow, but in the ecotone there was one colony which persevered throughout the study, and this was the only colony discovered in both 1966 and 1967; in the ecotone, however, in 1965 there was an additional colony present. The wooded quadrat had one colony for each of the three years, and this nest was apparently the same for 1965 and 1966, but had disappeared by 1967; however, in that year another nest of _Formica lasioides_ was located. Even on the basis of this meager evidence, it appears that nest stability in this species is quite high.

The other species of the subgenus _Proformica_ which was recorded is _Formica_ (_P._) _limata_ Wheeler. This is an ant which has as its range the southern Rocky Mountains in Colorado and New Mexico, and the mountains of eastern Utah; it is also found in North Dakota and northern Minnesota. It is classified as uncommon on the basis of 20 records by 1963. Although Colorado is in or near the probable center of its range, this ant is not at all abundant. It seems to be fairly tolerant of dry conditions. This ant has a strongly shining surface and an almost hairless thorax.

Formica (_P._) _limata_ Wheeler was extremely rare in my research area; it was never found in the ecotone or meadow; it was located in the wooded quadrat in 1967, and then in a compound nest with _Tapinoma sessile_ (Say).

The second of the three subgenera of the genus <u>Formica</u> is <u>Neoformica</u>. The members of this group build rather obscure nests, and the colonies are relatively small in size. The nests are usually under stones or at the base of tufts of grass, and since these ants are very timid, they will generally make no effort to defend the nest. They often abandon the brood, although they often sneak back and try to rescue it later. Because they do not battle with other ants, they are easy victims of slave-making species. There were two species of this subgenus discovered in my study.

<u>Formica</u> (<u>N.</u>) <u>pallidefulva</u> Latreille has the following range: Virginia to Florida and west to Texas and Kansas, with sporadic occurrences northward along the east coast, in the middle west, and in Colorado. Gregg classified it as rare in Colorado based upon 4 records as of 1963. Creighton describes this insect as austral with a broad distribution in the southern and eastern United States. The stations from which Gregg (1963) secured <u>pallidefulva</u> were at the base of the foothills along the eastern mountain front, and here summer temperatures are high, and winters comparatively less severe. In my research area, with one exception, this ant's nests were beneath stones. The exception was a flattened can which apparently served its purpose well, since that particular site (ecotone nest number 15) was occupied by probably the same colony for the entire three years encompassed by this study. Incidentally, insofar as collection of samples of this species was concerned, I had to work very quickly in order to collect enough for an adequate sample. This insect is victimized by thief ants, as I discovered it in four lestobiotic associations with <u>Solenopsis</u> (<u>D.</u>) <u>molesta</u> <u>validiuscula</u>

Emery. In one of the four stations, three colonies were under the same rock, and the third species was _Tapinoma sessile_ (Say).

Formica (_N._) _pallidefulva_ Latreille was common in my study area, for in 1965 in the ecotone 32 colonies were located, and of these, five (16%) persisted for all three years. Four more were present also in 1966, but were no longer there in 1967; however, in 1966 in the ecotone 22 nests were recorded, and in 1967 there were 21. In the forest six nests were discovered in 1965, but only four in 1966 and six in 1967. Two colonies were at the same site from 1965 to 1966, but all others were new locations. No colonies were ever found in the meadow. It is interesting that in three cases, colonies discovered in 1965 had no ants in 1966, but had the same sites in 1967. In view of the above, it can be seen that this formicid is quite unstable in its nesting habits.

The second species of the subgenus _Neoformica_ discovered in my study is _Formica_ (_N._) _pallidefulva nitidiventris_ Emery. Its range is southern Quebec and Ontario to the mountains of northern Georgia, and west to the Dakotas, Wyoming, Colorado, and northern New Mexico. Its occurrence is uncommon, based on the collection records as of 1963 which were 47. This subspecies replaces the typical _pallidefulva_ over the northern half of the United States east of the Rocky Mountains, and in the Rocky Mountain states themselves, it is by far the most common member of the subgenus _Neoformica_ (Gregg, 1963), but this was not the case in my study area, since _Formica pallidefulva_ was much more numerous. It was formerly believed to occupy only the eastern foothills, but there is now abundant evidence to show that it occupies a broad territory in

Colorado, which includes low elevations on the western slope. The majority of its records are from the lower foothills. As mentioned previously for _Formica pallidefulva_, it was also true for _Formica nitidiventris_ that, since these ants are so timid, in collecting them, I had to move quickly in order to obtain a minimum sample.

Formica (_N._) _pallidefulva nitidiventris_ Emery was not located in the ecotone; however, in the wooded quadrat two nests were found in 1965 which did not have any ants in 1966. A third colony was discovered in 1967 at a different nest site. In the meadow one colony was brought to light in 1965, and this one endured all three years at that site. In 1966 another colony was found, but this one was no longer present in 1967; however, in the latter year, two new colonies were located. From these results, one can but conclude that considerable instability existed, insofar as this species is concerned, for only one colony was present all three years.

The subgenus _Formica_ was represented by four species of ants, two of which are in the _fusca_ group, and two in the _rufa_ group, and the latter group includes mound-building species, which embrace many variants. The nests are very often thatched in the _rufa_ group, and many members of that group are temporary social parasites. In the _fusca_ group the species show a preference for nesting in the soil. They are ubiquitous and also very timid (ideal for slave-making).

Of the _Formica fusca_ group, two species were located. One of these is _Formica fusca_ Linnaeus, which is the very common "black ant" met in varying environments in prairies, foothills, and mountains. Its range is Holarctic; in North America from Newfoundland west to

Alaska and the entire northern half of the United States with southern extensions along the major mountain ranges into North Carolina and Tennessee, New Mexico and Arizona, and into California. It is classified as abundant on the basis of a total of 277 Colorado records as of 1963. This ant is probably the best known ant in the Northern Hemisphere, and it is absent from few major habitats, but prefers to nest in the soil. It is certainly among the most common of Northern ants, but in semi-arid regions, its occurrence tapers off sharply, and it is also limited by the upper timberline; for Gregg (1963) never found any established nests in the alpine tundra. Also, he never found any _Formica fusca_ in the plains grassland habitat.

In the meadow area I only found one record of this species and only in 1967, and none were found in the ecotone. The nests, except for the one in the meadow, were all located in the wooded region, and these were often found near the base of trees.

Formica fusca has broad elevational tolerances and appears to be abundant at high altitudes and extends somewhat higher than _argentea_. The members of this species lack pugnacity, for they are usually regarded as cowardly and timid, but docility may be a better term than cowardly, since the individuals which have been brought into the nests of slave-making species acquire all the pugnacity of their captors. In any case, they appear to be ideal subjects for slave-making. They are also ubiquitous, which is another advantage for the slave makers.

As stated above, _Formica fusca_ Linnaeus was not discovered in the ecotone at any time; in fact, it was not located in the meadow in 1965 nor 1966; however, one nest was observed in 1967. The forest in 1965 held nine colonies, one of which was extended throughout the three years (11% stability), and another continued into 1966, but was terminated by 1967. In 1966, seven nests were present, and in 1967 eight. From the above information, it is probably safe to conclude that Formica fusca is very unstable, insofar as nesting habits are concerned.

The other species of the fusca group found in my study area was Formica fusca argentea Wheeler. Its range is New England and the midwestern United States, and all of western United States from New Mexico, Arizona, and California to Montana and Washington with an extension into British Columbia, but is not found over the entire Holarctic or even Nearctic range of the typical fusca. According to Gregg (1963) geographically argentea is much commoner in western United States, and this area would seem to be its distributional center. Fragmentation of the range of fusca by the late glaciation may have led to isolation of a portion of it in the western and southwestern United States, giving a chance for accumulation of traits found in argentea. Now there is extensive hybridization between the two. Although argentea appears to extend far to the east, it is much more abundant in the west, and although its range is now engulfed by fusca, it would appear to have originated in the western states. It is classified as common in Colorado, since the number of records as of 1963 was 77. This species has broad elevational tolerances, and its altitudinal range is also like fusca. The former is more abundant at lower elevations and appears to extend a little lower than fusca, as it seems to be at home on the plains, especially the short-grass prairie. Gregg once found this species living in close association under the same rock with a colony of Lasius (A.) murphyi Forel. Like fusca, these ants also are timid, and are brought into the nests of slave-making species. Formica fusca argentea Wheeler was rare in my study. It was only discovered at one site in 1965 in the meadow.

As in the case of the fusca group of the subgenus Formica, the rufa group also produced two species in my research area. One of these is Formica obscuripes Forel, and the range of this ant is northern Indiana and Michigan westward across the northern United States and southern Canada to Oregon and British Columbia, with a southern extension through Utah and Colorado to northern New Mexico; Lake Tahoe, California. Its classification is abundant based on 119 Colorado records as of 1963. This species is probably the commonest thatching ant of the western states, and is most prevalent between 5000 and 8000 feet. It builds large, dome-shaped nests composed of thick masses of coarse plant debris (most often twigs), and would appear to inhabit a variety of vegetation types; however, Smith (1962) found one small nest beneath a rock. The finished mound does not depend upon any support for the detritus, but it is believed to be begun around the base of a small plant. Gregg's data corresponds with these descriptions, and the colony I found, which was present all three years, also gives support to the above information. The ant appears to prefer clay soil, but a wide variety of general habitats is used by this species, and it is one of our most eurokous formicids. Cole (1932) states that the colony always contains two or more queens, and that winged males and females are present in large numbers through June and July. Weber (1935) showed that a typical marriage flight does not occur in Formica obscuripes; instead, reproductives come from the nest singly, or in small groups during a period of several weeks. Formica obscuripes Forel workers also appear to attend aphids on various flowering herbs. I found this ant to be very aggressive. The best known mound maker of the rufa group is Formica obscuripes, and its nests often form a conspicuous feature of the landscape in the west. There appears to be controversy over whether obscuripes females are temporary social parasites. Wheeler thought most, if not all, species of the rufa group were probably temporary social parasites, but Creighton does not believe this applies to obscuripes as well as some other species of rufa.

Two colonies of Formica obscuripes were recorded, and both of these were found in the meadow. One colony persisted all three years, but the other was found in 1966, (Lasius (A.) latipes (Walsh) occupied the nest site in 1965) and persisted in 1967. The latter nest was smaller than the former; however, the nest which had been discovered in 1965 was much smaller by 1967, for it appeared to have been damaged by some object, and was much reduced in size. The stability of the nests of this insect must be classified, on the basis of these two colonies, as excellent.

The other species of the rufa group of the subgenus Formica is Formica obscuriventris clivia Creighton. Its range is Iowa, Wisconsin, and Manitoba west to British Columbia, with a southern extension in the Rocky Mountains to Colorado, Utah, and New Mexico. It is classified as uncommon based on 47 records by 1963. The typical subspecies of this ant is an eastern and midwestern insect, and is extremely rare and erratic in this region. The great majority of records Gregg has seen belong to the western subspecies clivia. Intergradation and hybridization of the latter with the former occurs from Minnesota to Illinois, but the region may be larger, and hybridization probably occurs in Colorado as well, due to the range overlap here. This formicid is most abundant in Transition Zone communities, with a sharp drop above and below these levels, but it is known from four zones.

Gregg found the greater number under rocks and most frequently in rich, loamy soil. I discovered one nest in the ecotone every year at the same station, which presumably was the same colony. The nest stability for this species based on this one nest each year is 100%, but, of course, if more than one colony had been found, this stability might have been less than 100%. This evidence is much too meager to establish a generalization on nest stability.

The third subfamily represented in my quadrats is the Dolichoderinae which has representatives which are rather uniform in both habits and structure. They prefer to nest in soil and show little evidence of dietary specialization, and because of the latter, they have become serious household pests. Three genera with one species each were discovered in my collecting sites.

One of the three species located is Iridomyrmex pruinosus analis (E. André), which has the following range: California east to Texas, Oklahoma, and Kansas; north to southern Idaho. Its occurrence is uncommon based on 36 records established by 1963. This ant appears to enjoy hot, dry localities; however, it is not absent from certain rather moist situations also, such as canyon bottom forests. It will nest under covering objects, but is often found with nest openings exposed, surrounded by craters of discharged soil. The ant is difficult to collect, since it moves very quickly, especially in bright sunlight, which markedly increases the temperature of the soil. These insects are entomophagous, and all nest in soil.

Iridomyrmex pruinosus analis (E. André) was discovered in my research area at three different stations. Two of these were in the ecotone, and were found in 1965, and one of these colonies persisted through all three years, but the other was not found in 1967. The third colony was discovered in the wooded quadrat. Therefore, only one third of the nests had stability throughout the study period.

The second of the three Dolichoderinae species is Liometopum occidentale luctuosum Wheeler. Its range is southern Wyoming to New Mexico and Arizona, and the mountains of California; it is rare in Utah and Nevada. Based on 29 records established by 1963, it is considered uncommon. Wheeler (1917) considered Liometopum luctuosum to be quite rare, more so than Liometopum apiculatum, but as far as its presence in Colorado is concerned, just the opposite is true. Wheeler also wrote that luctuosum is associated with pine trees (or at least conifers), and has its nests under the roots of these trees. Gregg (1963) writes that it is frequently associated with evergreen vegetation, but it is by no means limited to that type. All the records I have of this species are in the wooded area which is, of course, Ponderosa pine.

Creighton points out that the ants in this genus are more agressive than those of most of the Dolichoderinae genera. These are very pugnacious insects, which forage in files and attack fiercely if disturbed. They have a secretion with a powerful and disagreeable odor like that of butyric acid and spray this on intruders. The nests are usually built under stones or in hollow trees, and the nest chambers are sometimes subdivided by a mass of paper-like material which they manufacture by mixing bits of soil and vegetable detritus with a secretion which hardens and causes the mass to become solid. The North American species of _Liometopum_ will tend aphids and coccids. This ant will feed upon any insects it can capture. According to Creighton, it has a preference for nests at higher levels (4000-7000 feet) than _Liometopum occidentale_, and therefore, keeps its range largely separate from the latter. This is rather difficult to understand, since both _luctuosum_ and _occidentale_ are foothill ants.

For _Liometopum occidentale luctuosum_ Wheeler no records were established in the ecotone or meadow; however, in the forest in 1965 seven sites were located; one of these persevered for all three years. In fact, in 1966 only three nests were discovered, and in 1967 only the nest which extended through all three summers. Of the seven colonies, then, which were present in 1965, only one nest (14%) was stable for the duration of this research study; another 14% was still present in 1966, but absent in 1967, therefore, stability of nests in this species was poor.

The third and last of the Dolichoderinae species is _Tapinoma sessile_ (Say). Its range is southern Canada and the entire United States except the southwestern deserts, and it can certainly be classified as abundant, based on 199 records established by 1963.

In view of its broad range, it can be considered ubiquitous, for this ant is obviously extremely adaptable and tolerant, but it is absent from tundra and in exposed areas in forests near timberline. Also, there are none of these ants in saltbush deserts of Colorado. Gregg observed plesiobiotic relations in this ant on two occasions, for in one case, Tapinoma was living under the same rock in close proximity to a colony of Lasius (A.) murphyi Forel, and in the other, with a colony of Lasius (A.) claviger (Roger). Creighton writes that Dr. M. R. Smith's observations of Tapinoma sessile are that it is not at all particular about its nest sites, which it changes frequently, and will nest in the soil, with or without a covering object, under bark, and in all sorts of preformed cavities, and it also becomes a pest in houses. Furthermore, it has a remarkable elevational tolerance, since it occurs from sea level to sub-alpine areas. The workers usually forage in files and are omnivorous, although they appear to prefer honey-dew and sweet foods when they can get them. Tapinoma is an energetic ant; it is not timid but less combative and bad tempered than many ants. This is why on occasion it forms compound nests with other ants. The Tapinoma odor is due to butyric acid.

Insofar as Tapinoma sessile (Say) is concerned, in my study area it proved ubiquitous, since it was found in all three quadrats; however, it was by far most abundant in the wooded region. The ecotone had six nests in 1965, but these were vacated in 1966 and 1967; however, one colony was discovered for each of the latter two years. The forest in 1965 yielded 19 nests, none of which continued throughout the three summers. In fact, only two were found at the same sites in 1966, but in that year three new nests were located. The wooded quadrat in 1967 rendered eight nest sites none of which were occupied by Tapinoma sessile in 1965 or 1966, for most of these had been occupied by other species in 1966; only two were new nest sites. Even before one considers the meadow, it is obvious that great nest instability exists in Tapinoma sessile. It is of interest that in 1965, of the six sites which housed sessile, not a single one of these six sites had any species of ant in 1966. This condition was a very common occurrence in most species in my study, in that where nests were occupied by a particular species in one year, very often the next year when that species was not present, no other ant was present at that site either. Tables I - IX demonstrate this time and again. In 1965 there were two nests in the meadow; in 1966 there were two located at different sites, and in 1967 there was only one colony which was discovered at a new site.

From the descriptions of the results of the collections of the ants in my quadrats, over the period of three years, from 1965 through 1967, it is quite obvious that the majority of ants in my study were quite unstable insofar as their nesting habits are concerned.

Creighton writes that Tapinoma sessile (Say) changes its nest sites frequently. Wheeler (1910) writes of the migration of Formica sanguinia which often has summer and winter residences, and uses the expression "analagous to the city and country homes of wealthy people." The summer nests are built in open, sunny locations where food is plentiful and conditions are most favorable for rearing the brood, whereas, the winter nests are built in secluded spots in the woods and are used as hibernacula or, very rarely, for protection from the excessive heat of summer. Wheeler says that the migration of ants from one nest to another is determined upon, and initiated by, a few workers, which are either more sensitive to adverse conditions, or of a more alert and venturesome nature, than the majority of their fellows. After they select a site, these workers begin to deposit their brood, queen, males, fellow workers, and even their myrmecophiles.

Two types of ant nests are distinguished according to Wheeler (1910)—the temporary and permanent, without any corresponding differences in architecture. Wheeler compares this to Forel's distinction of monodomous and polydomous colonies. The nest of the former colony is a single circumscribed unit, whereas a polydomous colony spreads over several nests, the inhabitants of which remain in communication with one another and may visit back and forth.

Brian (1965) claims that most mortality of nests occurs before they are even started, since it depends upon the survival of the queen. Most causes of nest loss are still unknown. Brian writes that a favorite method of studying ant colony survival is to mark and measure their mounds. In species that construct mounds, those mounds which disappeared probably did so through shading, through human interference, or from unknown causes. Talbot (1961) noticed that many mounds of a species of Formica ulkei in Michigan were formed and then abandoned. These mounds may not have necessarily died—they may have returned to their parent colony, and so, perhaps, represent trial buds that proved unsuccessful. Scherba (1961, 1963) studied the population dynamics of Formica opaciventris, which reproduces by budding following pleometrosis, and between 1957 and 1959 small mounds had as high as 35% mortality. The large mounds are destroyed by destructive forces, shading, exhaustion of local resources, predation, and other causes still unknown. More data for many other species are needed to determine the causes of nest mortality. Trampling and cultivation destroys many ant nests and severely restricts the areas that are inhabitable.

Although Pickles (1937 and 1938) described changes of ant nest distribution, and Brian (1952) worked on the replacement of nests under stones, Yasuno (1965) writes that there is no quantitative investigation on the change of the ant population. To analyze the population dynamics of the ant population, a consecutive study was accomplished at the Kayano grassland on Mt. Hakkôda, which is situated in the northern part of the main island of Japan, during the period 1957-1961. Yasuno found that the ant population is in a dynamic state. The number of nest-mounds of _Formica truncorum yessensis_ change seasonally, but the number of nests of this species and _Camponotus herculeanus japonicus_ seems to be constant. As for _Formica fusca japonica_, the number of nests is also nearly constant. A stable state is maintained apparently in the number of nests, but stability of individual nests is very low, especially in _F. fusca japonica_.

Lincoln Index

Another purpose of this study was to determine the value of the Lincoln Index in determining the number of individuals in an ant colony. Table XV presents the results of this work, and with exception of one colony of Camponotus, it can be seen that the density determined by actual count is greater than that figure derived from the use of the Lincoln Index. In other words, the use of the index in my study resulted in great underestimation of the size of the colony.

Andrewartha and Birch (1954) write that it is important that either the initial marking or the subsequent catching be done evenly over the area selected for study, because of the following assumptions which the index requires: a. the marked individuals redistribute themselves at random to the unmarked ones; b. the marked ones are neither more nor less readily caught than the unmarked ones; and c. between the times of release and recapture there have been no gains or losses by births, deaths, or migration.

Golley and Gentry (1964) used the mark-recapture procedure with the southern harvester ant, Pogonomyrmex badius, and the technique produced contradictory results. These workers found that the use of the index depended on the following assumptions: a. all normal workers forage, b. marked and unmarked ants mix in the hill before the second sample is withdrawn, and c. the radioactive phosphorus which was used for labeling the ants, adheres to the tagged ants until the sample is taken, yet is not transferred to other ants within the hill. The tagging and excavation experiment was unsuccessful for this species, since the radioactive phosphorus spread to other members of the colony. Also, tagged ants were only in the upper part of the hill, with the majority in the uppermost 10 centimeters, and this suggests that the ants do not mix within the hill (at least for short periods of time) and that all the workers do not participate in foraging activity. It has long been known that ant workers, like honey bees, remain in the nest as nurses for a time after hatching from the egg and begin foraging as they age. Incidentally, Golley and Gentry found that movements of ant hills is a common phenomenon in these ants. The authors use the term movements of ant hills to mean migration from old to new hills. The results of Golley and Gentry's work support Chew (1960), who worked with Pogonomyrmex occidentalis (Cresson) in Arizona. Chew, using similar methods, found that only about one half of the workers were active at the surface and that random mixing within the colony did not take place. I consulted Dr. Chew at the University of Southern California, Los Angeles, and it is Chew's opinion that since many workers do not forage, the Lincoln Index underestimates the size of the colony, and therefore the index may be useful in estimating the density of foraging workers.

Climatic Conditions

Brian (1965) found that in woodlands the colony densities of various ants are remarkably high, and figure VIII and table XII show that the wooded area had not only the largest number of nests per year, but also the greatest species diversity as well. This quadrat was in a ponderosa pine forest facing north by northwest and is a very favorable location for ants. The meadow also faced north by northwest, but upon examination of figure IX and table XIII it can readily be seen that there is a distinct paucity of ants here in comparison with the forest. The ecotone faced east by southeast but mostly east. This quadrat had a considerable number of nests and species each year but not to the extent of the wooded quadrat. According to Wheeler (1910), colonies of ants in hilly or mountainous country are usually more abundant on the east and south exposures. My study proves to be an exception to the above, but as Gregg (1963) writes, general observations do appear to support Wheeler, although the whole question needs further study. Gregg also found that ants which are confined to tree-covered environments or which use both arborescent and open environments form the bulk of the ant fauna of Colorado. This statement is certainly supported by my findings. He adds that grassland and desert occupy the more level and more arid regions, and their ants contribute a much smaller proportion of the total fauna.

As noted previously, temperatures were taken two to three inches below the surface of the ground, at the surface, six inches above it, and five feet from the ground. As stated by Gregg (1963), in spite of the importance of atmospheric heat to all forms of life, the temperature of the soil is of particular significance to myriads of organisms, because so many are in direct contact with it. The invertebrates in soil faunas, of which ants form a conspicuous part, are subject to soil temperatures virtually throughout their lives, except for short periods like the nuptial flights of ants. Gregg believes it is logical to consider surface temperature as properly a phase of soil temperature, since it is a measure of heat generated by contact of light with the soil. Further, surface temperatures may reach critical upper limits of tolerance for minute organisms before either the air or the internal soil temperatures, and the soil surface is the place where so many of these organisms carry on a large percentage of their activities. Hence, its importance should not be ignored. The air temperature immediately above the surface also has an important influence on the activities of these small terrestrial animals, and consequently these measurements were included in my work. Air temperatures show greater fluctuation than soil temperatures.

Even a cursory examination of the tables showing raw data reveals a distinct variation from one quadrat to the other for each of the four different types of temperature recording areas. As noted previously, tables XIX, XX, and XXI show weekly morning, noon, and afternoon temperature averages in all quadrats for the various localities at which temperatures were measured. In the morning, the woodland subsurface temperatures consistently averaged lower than the meadow temperatures but higher than those in the ecotone. The noon and afternoon subsurface temperatures showed the forest intermediate between the ecotone and the meadow.

Insofar as the weekly morning surface temperature averages are concerned, in three of the five weeks (60%) the forest temperatures averaged below those of the meadow and the ecotone. According to Chauvin (1967), forest insects do not receive anything like the same radiation as those which live out in the open air, since the forest floor receives only a low percentage of the sun's radiation. The forest, however, was intermediate between the ecotone and meadow in averages of my weekly noon surface temperatures. The morning temperature means for the station six inches above the ground were lower in the forest than in the ecotone and meadow for three weeks of the five, and at noon and in the afternoon the forest temperatures were intermediate between the ecotone and the meadow.

The meadow consistently had the highest temperatures of all three strata---subsoil, surface, and six inches above the surface. Radiant energy from the sun is a source of heat for insects, and both visible light and infrared rays will serve to heat the body above the surroundings. The radiant energy can cause the temperature to go high enough to cause the insect to retreat to a shady spot such as the nest and therefore curtail its activities. This is probably an important factor in limiting the number of colonies in the meadow, since insects may find themselves beyond their optimum temperature due to the sun's rays reaching the soil. Weekly averages for temperatures taken five feet from the ground revealed similarities to the other temperature-recording stations. It should be remembered that the stratum five feet from the ground should not have as great an influence on the ant as the other levels, but for ants which forage on plants at that height there would be an influence.

The ponderosa pine forest's subsurface weekly morning temperature averages were higher than those of the soil's surface in the forest in four of the five weeks. In the ecotone this was the case in only two of the five weeks, and in the meadow the situation was like that of the forest. The deeper soil apparently retains some heat from the previous day, whereas the surface has cooled considerably during the night. The morning soil warmth would probably stimulate activity in the adult ants and growth in the young.

Weekly temperature averages six inches above the ground in the morning were generally higher than the surface temperatures in every week and in every quadrat, but one week saw the same temperatures at both recording stations in the forest, and one week in the meadow the surface temperature was higher than that of the stratum six inches above the ground.

At noon subsurface weekly temperature averages in all quadrats were lower than at the other three recording stations. In the meadow the surface temperatures were higher than those taken six inches above its surface in three out of five weeks (one week they were the same). This fact would limit foraging activities if temperatures were above the optimum. In a comparison of the noon temperatures five feet above the ground with the surface reading, the meadow had higher weekly average temperatures in every case at the surface. In the forest only one week saw the surface temperature warmer than the temperature taken five feet above the ground, and in the ecotone the surface was consistently cooler than the temperature five feet above the ground. This observation is another possible reason for a greater number of ant colonies in the forest and ecotone.

In the afternoon the forest had a higher weekly average surface temperature as compared to its subsurface reading in three of the five weeks, but the surface temperature in the meadow was not higher than the subsurface in any week. The ecotone had two out of five weeks of surface temperature averages higher than subsurface. This fact would appear to indicate that the forest has a more constant daily temperature which permits a longer foraging and activity period. Chauvin (1967) says that during the day, the underwood having quickly reached its equilibrium, this condition will remain with remarkable consistency throughout the day. During the night the temperature stays uniform all through the forest with two zones of minimum temperature, one on the floor where heavier cold air sinks, and the other in the treetops. This is in agreement with my results, since the majority of the five weeks revealed lower surface temperatures in the wooded area, in the mornings, than in the other two quadrats.

Since weekly maximum and minimum temperatures may be of even greater significance than weekly temperature averages as noted previously, tables XXII, XXIII, and XXIV were prepared. These show weekly morning, noon, and afternoon temperature extremes in all quadrats at each of the four temperature recording locations. Insofar as temperature extremes were concerned, there was a much greater range from maximum to minimum temperatures from the highest station (5' above ground) to the lowest station (subsurface) and in that order.

Means were calculated for the weekly maximum and minimum morning subsurface temperatures. The results for average maximum temperatures are: ecotone--63.6, forest--64.8, and meadow--66.5; average minimum temperatures: ecotone--59.0, forest--60.4, and meadow--61.8. The forest was intermediate between the ecotone and the meadow, and the forest appears to have morning subsurface temperatures which are less variable than those in the other quadrats. The means of the weekly maximum surface temperatures in the morning are: ecotone--67.5, forest--68.6, and meadow--68.1. It is apparent that the forest maximum surface temperature is generally higher than in the ecotone or meadow, which makes possible a longer daily period of activity for the ants in this quadrat. However, the slight temperature differences may or may not be significant. The ants usually are exposed to a higher morning temperature, and may, therefore, begin foraging and other activities earlier in the day.

The lowest weekly morning temperature recorded for any quadrat at the three stations in or near the ground during the recording period was for the ecotone (46.5°). The forest was intermediate between the ecotone and meadow in the means of the weekly temperature minimums for the two stations below and at the ground's surface. For stations at, below, or six inches above the ground, the highest weekly morning temperature recorded was in the forest (80.9°). The ecotone had 80.5° as its maximum, and the meadow had 78.3°. This temperature in the forest was at six inches above the surface, and this would probably indicate an earlier start in activity for the ants in the forest, that is, if the temperature differences are significant. Four-tenths of 1° between the ecotone and forest is not a large difference, although the difference between the forest's 80.9° and the meadow's 78.3° is greater.

It can be seen in table XXIII, which shows weekly noon temperature maximums and minimums, that the forest was intermediate between the meadow, which generally had higher maximums and minimums than the forest, and the ecotone, which had the lowest maximums and minimums.

Means were calculated from the weekly figures for the noon temperature extremes. These are

Subsurface
  Maximum
    ecotone--64.6
    forest--68.3
    meadow--73.0

  Minimum
    ecotone--60.1
    forest--62.4
    meadow--66.5

Surface
  Maximum
    ecotone--80.3
    forest--84.5
    meadow--87.0

  Minimum
    ecotone--63.6
    forest--65.1
    meadow--69.6

Six Inches Above the Surface
  Maximum
    ecotone--81.1
    forest--85.3
    meadow--87.2

  Minimum
    ecotone--64.4
    forest--66.4
    meadow--67.4

It is apparent from these figures that the forest has a middle position for noon temperature extremes.

From table XXIV we can see that for afternoon weekly temperature extremes at both the surface and six inches above the ground the wooded quadrat often had higher maximums, but minimums were between those for the ecotone and the meadow.

Means from the weekly figures were calculated for the afternoon temperature extremes. These are

Subsurface
    Maximum
        ecotone--66.6
        forest--71.9
        meadow--75.0

    Minimum
        ecotone--61.2
        forest--64.7
        meadow--67.3

Surface
    Maximum
        ecotone--77.5
        forest--81.2
        meadow--81.1

    Minimum
        ecotone--61.2
        forest--63.8
        meadow--66.4

Six Inches Above the Surface
    Maximum
        ecotone--78.6
        forest--80.5
        meadow--81.4

    Minimum
        ecotone--60.9
        forest--61.1
        meadow--65.2

It may be noted that in the afternoon on the surface the mean temperature maximum for the forest was 81.2°-- higher than the ecotone, and slightly higher than the meadow; this observation may serve as evidence for a longer daily temperature range for foraging and other activities. Minimum mean temperatures for the woodland were consistently between those for the meadow and the ecotone. Since much of the activity of ants occurs on the soil and a few inches above, it would appear that temperature is a very important factor in the wooded quadrat, since it is very favorable there much of the time. One can conclude from these tables that there is considerable variability between the three samples taken daily from each quadrat.

Upon examination of table XXXII, which shows the average daily and weekly per cent of moisture in all quadrats in the first three of the four weeks, it may be seen that the average per cent moisture was highest in the meadow, but it was highest in the ecotone the last week, and in the forest the per cent moisture was higher than in the ecotone for one of the four weeks. Based upon the four weekly figures for all quadrats, the monthly mean percentage of moisture is as follows: ecotone 11.52, forest 10.51, and meadow 12.76. Obviously, the woodland had a smaller percentage of moisture during this period. Perhaps the soil moisture or humidity is more ideal in the forest, since it is true that the rate of development in some organisms is retarded at high humidities. Also, it is probable that excess moisture may cause mortality in terrestrial insects due to fungus and other related pathological agents.

According to Gregg, moisture is perhaps less limiting than temperature; however, the meadow may be an example of a case of excessive moisture. Certainly, the moisture and temperature combination provides suitable conditions for ant colony formation in the ecotone, but these two factors may interact in the wooded area more advantageously than in the ecotone, for there were so many more ants in the forest, and also more species. However, other factors may also be influential in the wooded quadrat, such as soil, vegetation, and food availability. For instance, according to Chauvin (1967) the rain which reaches the soil after leaching the leaves on the trees has been changed chemically and in particular has become richer in mineral salts. It may contain 4 to 20 times as much calcium and 10 to 50 times as much potassium as the rain that falls on open ground. This helps to modify the litter of dead leaves, and the insects living there cannot fail to be affected by it. This would have only an indirect effect upon ants, however.

Foraging Activities

Four species of ants were observed insofar as their foraging activities are concerned, and Camponotus (T.) vicinus Mayr ant workers were often observed climbing trees in their search for food. Formica fusca Linnaeus workers were seen foraging on and under the bark of the ponderosa pines. In my observations of Formica obscuripes Forel, I found that it probably forages for considerable distances. Only one nest of this species was discovered in 1965, and in the quadrat in which the nest was located, the meadow, foragers were seen as far away as approximately 75 meters from the nest. Columns of formicines of this species were seen moving along trails carrying food and thatching materials, and the columns were followed and traced to the mound nests. Since in 1965 only one colony of this species was located in the meadow, it is very probable that the foragers which were followed originated from the observed nest. Creighton (1950) writes that Iridomyrmex pruinosus analis (E. André) are very active in spite of their rather small size, and they forage in files. This investigator observed these foraging files on two occasions. The ants appear to follow a scent path produced by a pheromone, as in one case I drew a finger across their path, which caused great confusion.

Nest Evacuation

There may be many reasons for ant nest evacuation. In my own research area, it was observed that often wherever ant nests had been vacated, a white mold was seen under the stone where the nest had formerly been. Possibly secretions of the mold may be undesirable to ants. Then, too, quite frequently where nests had been vacated a large spider would be found under the rock, and since spiders are predaceous, they may have been a major cause for departure from a nest. I always tried to be careful in sampling the nests, but this practice may have been responsible for the ants vacating the nest too. Flooding may have eliminated some nests, since run-off in the spring is sometimes excessive. Microclimatic conditions, food sources, and ant territorialism must certainly be considered in evaluation of causes of nest abandonment.

Compound Nests

The ants in these compound nests were found under the same stone, but their colonies were separate (plesiobiosis, which has been defined in the Results section). Of the subfamily Myrmicinae, _Myrmica schencki emeryana_ was one of the 12 species of ants which had at least one compound nest. I found two compound nests for _Myrmica emeryana_ in which were associated _emeryana_ and _Lasius niger neoniger_ Emery in one case, and _emeryana_ and _Formica (N.) pallide-fulva_ in the other. _Aphaenogaster (A.) subterranea valida_ Wheeler was found near another species of ant under the same rock upon six different occasions. The ants with which _valida_ was associated in close proximity were _Tapinoma sessile_ (Say), _Lasius (C.) brevicornis_ microps Wheeler (two occasions), Formica fusca Linnaeus (two occasions), and Lasius (C.) umbratus aphidicola (Walsh). Solenopsis (D.) molesta validiuscula Emery was found associated with other species on four separate occasions. In three cases, Formica (N.) pallidefulva Latreille, and Solenopsis validiuscula were under the same rock, and in another instance, there were three species in plesiobiosis; these were Formica pallidefulva, Solenopsis validiuscula, and Tapinoma sessile. The last of the myrmicine ants having compound nests was Leptothorax rugatulus Emery with one nest in which it was closely associated with Lasius (C.) brevicornis microps Wheeler.

Of the subfamily Formicinae, Camponotus (T.) vicinus Mayr on one occasion was found associated with another species under the same rock, the other species being Lasius (A.) latipes (Walsh). Although Gregg states that Lasius alienus americanus Emery has been found living in plesiobiosis with Formica (P.) neogagates Emery, I did not find any cases where Lasius americanus lived in a compound nest with any other ant. Another formicine Lasius niger neoniger Emery was associated with another species under the same rock in two cases. These species are Myrmica schencki emeryana Forel and Lasius (C.) brevicornis microps Wheeler. I found Lasius (C.) brevicornis microps Wheeler in six different compound nests of two species per site in association with Lasius niger neoniger Emery, Tapinoma sessile (Say), Formica fusca Linnaeus, Leptothorax rugatulus Emery, and Aphaenogaster (A.) subterranea valida Wheeler (two records). Another member of the subfamily Formicinae, Lasius (C.) umbratus aphidicola (Walsh) was found by Gregg (1963) on one occasion associated with Leptothorax rugatulus Emery in at least a plesiobiotic relationship. In 1965 in the ecotone I found Lasius aphidicola under a rock associated with Formica (N.) pallidefulva Latreille. When the rock was removed, the two species did not appear to interfere with each other in any way. Gregg cites a nest of mixed Formica (R.) wheeleri Creighton and Formica (P.) neogagates Emery with a quantity of aphidicola which were all dead; presumably the aphidicola served as food for the other ants. Three members of the genus Formica of this subfamily (Formicinae) revealed at least one compound nest. Formica (P.) limata Wheeler was located in the forest in 1967 and in a compound nest with Tapinoma sessile (Say). Formica (N.) pallidefulva Latreille was found in apparent plesiobiosis with these species: Lasius (C.) umbratus aphidicola (Walsh), Myrmica schencki emeryana Forel, and Tapinoma sessile (Say). For the third member of the genus Formica, Formica fusca Linnaeus, Gregg recorded one instance of plesiobiosis and this was with Myrmica lobicornis lobifrons Pergande under a rock. I discovered two cases; one species with which Formica fusca was associated being Lasius (C.) brevicornis microps Wheeler, and the other species Aphaenogaster (A.) subterranea valida Wheeler.

Of the subfamily Dolichoderinae, one species, Tapinoma sessile living with at least one other species under the same rock on seven different occasions. The species associated with Tapinoma sessile were Formica (N.) pallidefulva Latreille, Aphaenogaster (A.) subterranea valida Wheeler (two records), Lasius (C.) brevicornis microps Wheeler, Formica (P.) limata Wheeler, and Solenopsis (D.) molesta validiuscula Emery. In one case, pallidefulva, validiuscula, and *sessile* were all under the same rock. Gregg also found a case where *Tapinoma* was a third member of three colonies under the same rock and *Solenopsis* (*D.*) *molesta validiuscula* Emery, which was also present, may have been lestobiotic (thieving) on the other two ants. In my records of three species in close proximity, *Solenopsis* may have borne the same relationship to the other two ants.

Polydomous Nests

Of the six species of ants which had probably formed as branches from the original colony, there were five belonging to the subfamily Formicinae, and the other species was a member of the Myrmicinae. The myrmicine ant is *Aphaenogaster* (*A.*) *subterranea valida* Wheeler, and I observed polydomous nests for *valida* on three occasions in the wooded quadrat. Of the Formicinae, in at least one instance, several nests of *Camponotus* (*T.*) *vicinus* found in the forest were very close to each other, and workers could be seen visiting other nests (polydomous situation). I observed *Lasius niger neoniger* Emery living in polydomous nests on two occasions in the wooded quadrat, and another species of *Lasius*, *Lasius* (*C.*) *brevicornis microps* Wheeler living in one polydomous nest in the same quadrat. Of the two *Formica* species which were found in polydomous nests, *Formica fusca* Linnaeus was observed on two occasions in the forest, and *Formica* (*N.*) *pallidefulva* Latreille was seen in a polydomous nest condition on three occasions in the ecotone.

Census of Colonies

I planned to count at least one colony from each species, and three, if possible, so that an average might be calculated. Unfortunately, not all species were counted although the majority were tabulated. There were several reasons for not counting all species, one being that many nests simply were vacated. Also, since in 1967 no stakes were inserted beside the newly discovered nests, these were difficult to locate again, and then, too, a few older stakes were missing. When this occurred, it was not difficult to identify the previous year's nest site, because of the preparation of detailed maps (see figures VII to IX) which had numbers for the various stakes. These numbers were not included in the figures, since they would have made them too cluttered, and, also they were not necessary for the purposes of the figures. In some cases, more than three nests were counted for a particular species. This was due to the fact that taxonomic identification was not accomplished until after the field work, and I sampled nests on the basis of previous records. Since a great deal of nest change and migration occurred, the result was seen in duplication of species counts. It is important to note that the actual counts of the colonies of the various ants would have been somewhat higher if all the foraging workers could have been included. However, since the absence of some workers occurred for all species, results will still be comparable to those which would have been achieved had all workers been counted.

In an examination of the tables for species composition (XI to XIII), it can be observed that in the ecotone in 1965 Formica (N.) pallidefulva Latreille was the dominant species insofar as colony numbers are concerned; however, colony-size average for this species was low at 76 members. Two other species, Camponotus (T.) vicinus Mayr and Aphaenogaster (A.) subterranea valida Wheeler, were both common in the quadrat and had higher individual colony population counts. The former had 100 individuals for average size, and the latter had 471. Therefore, all three of these species possibly exerted a dominant influence on associated ant colonies in the ecotone. Solenopsis (D.) molesta validiuscula Emery, Lasius (C.) umbratus aphidicola (Walsh), and Tapinoma sessile (Say) all were quite common in the quadrat, and the remaining ten species were rare and uncommon. This observation appears to confirm the well-known ecological principle that there are more rare or uncommon species than there are abundant species and that a few very common species may be far greater in numbers of individuals. In the ecotone in 1966, similar results were found as in 1965 but Aphaenogaster valida did not have as large a proportion of nests in comparison with Formica pallidefulva and Camponotus vicinus as before. In the ecotone in 1967 pallidefulva still led with the greatest number of colonies, but Solenopsis (D.) molesta validiuscula Emery now surpassed vicinus, and colony size in validiuscula averaged 221 which, of course, exceeded vicinus.

In the wooded quadrat in 1965 Aphaenogaster (A.) subterranea valida Wheeler was probably the dominant species with 25.4% of the colonies. This ant's colony size averaged 471 individuals, which compounded whatever influence it may have exerted in the quadrat. *Lasius niger neoniger* Emery was probably also important as a dominant, as it had 21.5% of the colonies, and its colony size averaged 399. *Lasius (C.) brevicornis microps* Wheeler and *Tapinoma sessile* (Say) also were probably important in their dominance in the quadrat. In 1966 in the forest the relationships were like those in 1965 except that *Camponotus (T.) vicinus* Mayr perhaps was somewhat more important as a dominant than *Tapinoma*. In 1967 in the forest, with exception of the fact that *Leptothorax rugatulus* Emery (average colony size 231) might have taken over *vicinus's* place in ecological importance in the quadrat, the relationships were the same as for 1965 and 1966.

In 1965 in the meadow *Lasius (C.) umbratus aphidicola* (Walsh) was dominant with 35.3% of the colony total, and these colonies were large with an average of 1852 individuals per nest so their importance was probably considerable. *Solenopsis (D.) molesta validiuscula* Emery (average colony size 221) and *Lasius alienus americanus* Emery (nest size 43) both possibly were important with 23.5% and 17.6% of colony total respectively. In the meadow in 1966 *Solenopsis validiuscula* now became the dominant (32% of colonies) over *Lasius aphidicola* (24%), and *Lasius americanus's* percentage dropped to eight per cent, a fact which caused it to be considered uncommon or rare. In 1967 in the meadow *aphidicola* again probably took over the leadership in dominance with 40% of the colonies, whereas *Formica (N.) pallidefulva nitidiventris* Emery and *Solenopsis validiuscula* tied with 15% each.

The species Formica obscuripes Forel in the meadow, Crematogaster lineolata (Say) in the forest, and Liometopum occidentale luctuosum Wheeler in the forest had low percentages of quadrat colony totals which would classify them as rare in the quadrat; however, the fact that they had the following average colony sizes would probably indicate that they had considerable ecological significance: obscuripes--3,330, lineolata--3,481, and luctuosum--1,215. Since obscuripes is also a larger ant and forages far afield, it should certainly be influential in its area.

As has already been noted, from one year to the next there appear to be changes in the numbers and ecological importance of various ants in their respective areas. It is of interest, therefore, to examine the 25 species and subspecies discovered in this study and determine the changes for these in terms of the nest numbers in 1965 and in 1967. The question is whether they remained constant in number. It has already been noted that most of the 25 species showed considerable individual nest instability.

Table XI shows species composition of the ecotone in all three years of the study, and of the 16 species found, two had the same number of nests in 1967 as in 1965. These are Formica obscuriventris clivia Creighton and Pheidole pilifera coloradensis Emery. Four increased in number: Lasius (A.) latipes (Walsh) and Crematogaster lineolata (Say) had no colonies in 1965 or 1966 but one each in 1967, while Camponotus (T.) vicinus Mayr and Solenopsis (D.) molesta validiuscula Wheeler also increased their colony numbers. The rest of the species declined in nest number from 1965 to 1967.

but, of course, in some cases, as in F. lasioides and Iridomyrmex, the decline was only one colony.

Table XII shows species composition for the wooded quadrat, and in this table, which depicts a total of 20 species, two had the same nest total in 1965 as in 1967. These species are Formica (N.) pallidefulva Latreille and Formica (P.) lasioides Emery. There are five species which showed an increase in nest total for the quadrat. Iridomyrmex pruinosus analis (E. André), Formica (P.) limata Emery, and Myrmica schencki emeryana Forel each had one colony in 1967 but no nests in 1965 or 1966, and Solenopsis (D.) molesta validiuscula Emery and Leptothorax rugatulus Emery also showed increases. All others showed decreases in nest numbers. In the forest, as in the ecotone, there are a number of species which have almost the same nest total in 1967 as in 1965 with a decline of only one nest.

Table XIII shows species composition of the meadow, and this table depicts a total of 10 species, three of which increased their nest totals. These are Formica (N.) pallidefulva nitidiventris Emery, Formica obscuripes Forel, and Formica fusca Linnaeus. The latter had no nests in 1965 or 1966 and only one in 1967. The other quadrat species decreased, but again, as in the other two quadrats, there are several species which decreased their 1965 nest total by only one nest in 1967.

Nuptial Flights

Sudd (1967) states that in temperate lands the mating flight is usually late in the year, and if he refers to late summer as being late in the year, a considerable number of my species support his thesis. Although no such flights were actually seen by this observer, the results are based on collection and observation of winged males and females in the various ant colonies.

In the ecotone in 1966, the following species were noted:

Lasius (C.) umbratus aphidicola (Walsh)
Aphaenogaster (A.) subterranea valida Wheeler
Camponotus (T.) vicinus Mayr (three nests)
Lasius alienus americanus Emery

In the wooded quadrat in 1966 the following species had winged members:

Aphaenogaster (A.) subterranea valida Wheeler (nine nests)
Lasius (C.) brevicornis microps Wheeler (four nests)
Lasius niger neoniger Emery (three nests)
Camponotus (T.) vicinus Mayr (two nests)

In the meadow in 1966, there were the following species with winged ants:

Lasius (C.) umbratus aphidicola (Walsh) (three nests)
Solenopsis (D.) molesta validiuscula Emery (four nests)

In the ecotone in 1967 the following species were observed:

Lasius (C.) umbratus aphidicola (Walsh)
Formica (N.) pallidefulva Latreille (three nests)
Lasius alienus americanus Emery
Crematogaster lineolata (Say)

SUMMARY

There were ten objectives or purposes of this study listed in the introduction. This summary will briefly relate the outcome of the research in terms of these objectives.

1. Twenty-five species and subspecies of ants were discovered in the research area, which consisted of three quadrats in a meadow, a wooded area, and an ecotone. Of these 25 species, nine are species found in two contiguous quadrats, which provides evidence that the plains-foothill boundary is an important biological boundary. Two additional species in the meadow did not penetrate the ecotone, which may help support the thesis that ants provide evidence of a boundary at the lower edge of the Foothill Zone.

2. Individual colonies of most of the species of ants found in this study are not very stable.

3. The Lincoln Index is not a very effective tool in estimating the size of ant colonies. It results in an underestimation of the size of the colony, since the Lincoln Index presupposes that all workers forage.

4. Moisture and temperature have very important effects upon ants. Temperature is especially significant for fossorial species, which includes the majority of ants. Temperature and moisture in the wooded area were especially favorable for ants, since the greatest number of colonies, as well as the largest variety of species, were located there.

5. Foraging activities, which were quite variable, were noted for four species of ants.

6. Causes for exodus from an ant nest may be excessive moisture, which results in flooding and subsequent growth of mold, disturbance to nests, food shortage, and possibly other causes.

7. A considerable number of ant species, of the 25 discovered, live in plesiobiosis, or compound nest associations.

8. Polydomous nests were found in six species of formicids.

9. Probable dominants among ants were noted for the three quadrats for each of the three years.

10. A considerable number of ant species have nuptial flights in late summer.

LITERATURE CITED

Allee, W. C., A. E. Emerson, O. Park, T. Park and K. P. Schmidt. 1949. Principles of animal ecology. W. B. Saunders Co., Philadelphia, Pa. 837 pp.

Andrewartha, H. G. and L. C. Birch. 1954. The distribution and abundance of animals. University of Chicago Press, Chicago, Illinois. 782 pp.

Armin, L. C. 1963. A study of the family Carabidae (Coleoptera) in Boulder County, Colorado. Doctoral thesis. University of Colorado. 465 pp.

Barrett, K. E. J. and J. C. Felton. 1965. The distribution of the wood ant, Formica rufa Linnaeus (Hymenoptera:Formicidae), in southeast England. Entomologist 8:181-191.

Borchert, H. F. 1956. The ant fauna of foothill canyons in the vicinity of Boulder, Colorado. Master's thesis. University of Colorado. 57 pp.

Brian, M. V. 1952. The structure of a dense natural ant population. J. Anim. Ecol. 21:12-24.

__________ 1965. Social insect populations. Academic Press, New York. 135 pp.

Brian, M. V., J. Hibble and D. J. Stradling. 1965. Ant pattern and density in a southern English heath. J. Anim. Ecol. 34:545-555.

Browne, J. T. 1958. A distributional study of the ant fauna of Gregory Canyon, Boulder, Colorado. Master's thesis. University of Colorado. 91 pp.

Byars, L. F. 1936. An ecological study of the ants of the plains region of Boulder County, Colorado. Master's thesis. University of Colorado. 52 pp.

Chauvin, Rémy. 1967. The world of an insect. McGraw-Hill Book Co., New York. 256 pp.

Chew, R. M. 1959. Estimation of ant colony size by the Lincoln Index Method. J. New York Entomol. Soc. 67:157-161.

__________ 1960. Note on colony size and activity in Pogonomyrmex occidentalis (Cresson). J. New York Entomol. Soc. 68:81-82.

Cole, A. C. 1932. The thatching ant, Formica obscuriventris Forel Psyche 39:30-33.

Creighton, W. S. 1950. The ants of North America. Bull. Mus. Comp. Zool. Harvard University. Vol. 104:585 pp.

Delfin, E. D. 1954. An entomological survey of Gregory Canyon, Boulder, Colorado. Master's thesis. University of Colorado. 61 pp.

Elton, C. S. 1932. Territory among wood ants (Formica rufa L.) at Picket Hill. J. Anim. Ecol. 1:69-76.

Forel, A. H. 1928. The social world of the ants compared with that of man. Putnam, New York. 2 Vols.

Francoeur, André. 1966. La faune myrmécologique de l'érablière à sucre (Acertum saccarophori, Dansereau) de la région de Québec. Naturaliste Can. 93:443-472.

Golley, F. B. and J. B. Gentry. 1964. Bioenergetics of the southern harvester ant, Pogonomyrmex badius. Ecology 45(2):217-225.

Gösswald, K. and W. Kloft. 1961. Beziehungen einiger im Walde lebender Mäuse zu Waldameisennestern. Waldhygiene 4:22-23.

Gregg, R. E. 1947. Altitudinal indicators among the Formicidae. Univ. Colo. Stud., Ser. D, 2:385-403.

__________ 1963. The ants of Colorado. University of Colorado Press, Boulder, Colorado. 792 pp.

Jackson, C. H. N. 1936. Some new methods in the study of Glossina morsitans. Proc. Zool. Soc. London. 811-896.

__________ 1939. The analysis of an animal population. J. Anim. Ecol. 8:238-246.

Knight, C. B. 1965. Basic concepts of ecology. Macmillan Co., New York. 468 pp.

Lincoln, F. C. 1930. Calculating waterfowl abundance on the basis of banding returns. U. S. Dept. Agric. Circ. No. 118.

Merriam, C. H. 1898. Life zones and crop zones of the United States. Bull. U. S. Dept. Agric., No. 10, 79 pp.

Messenger, P. S. 1959. Bioclimatic studies with insects. Annu. Rev. Entom. 4:183-206.

Odum, E. P. 1959. Fundamentals of ecology. 2nd ed. W. B. Saunders Co., Philadelphia, Pa. 546 pp.

In the forest in 1967 there were these species with winged ants:

Lasius (C.) brevicornis microps Wheeler
Aphaenogaster (A.) subterranea valida Wheeler (two nests)
Lasius niger sitkaensis Pergande
Myrmica schencki emeryana Forel
Iridomyrmex pruinosus analis (E. André)
Lasius niger neoniger Emery

The meadow had no nests with winged ants in 1967. It is of interest to note that some species appeared on the list in 1967, but did not in 1966.

Odum, E. D. and A. J. Pontin. 1961. Population density of the underground ant, Lasius flavus, as determined by tagging with P^{32}. Ecology 42:186-188.

Osborn, W. S. 1953. Estimates of alpine grasshopper densities as determined by modifications of the Lincoln Index. Master's thesis. University of Colorado. 53 pp.

Pickles, W. 1937. Populations, territories and biomasses of ants at Thornhill, Yorkshire, in 1936. J. Anim. Ecol. 6:54-61.

_________ 1938. Populations, territories and biomasses of ants at Thornhill, Yorkshire, in 1937. J. Anim. Ecol. 7:370-380.

Robbins, W. W. 1910. An introduction to the study of the ants of northern Colorado. Univ. Colo. Stud. 7(4):215-222.

Rodeck, H. G. 1964. Natural history of the Boulder area. University of Colorado Museum, Boulder, Colorado. 100 pp.

Scherba, G. 1961. Nest structure and reproduction in the mound-building ant Formica opaciventris (Emery) in Wyoming. J. New York Entomol. Soc. 69:71-78.

_________ 1963. Population characteristics among colonies of the ant Formica opaciventris (Emery) (Hymenoptera:Formicidae). J. New York Entomol. Soc. 71:219-232.

Schneirla, T. C. 1949. Army-ant life and behaviour under dry-season conditions. 3. The course of reproduction and colony behaviour. Bull. Amer. Mus. Natur. Hist. 94:1-81.

_________ 1957. A comparison of species and genera in the ant subfamily Dorylinae with respect to functional pattern. Insectes sociaux 4:259-298.

Smith, M. E. 1962. The distribution of ants in the vicinity of Valmont Butte, Valmont, Colorado. Master's thesis. University of Colorado. 67 pp.

Sudd, J. H. 1967. An introduction to the behavior of ants. St. Martin's Press, New York. 200 pp.

Talbot, M. 1934. Distribution of ant species in the Chicago region with reference to ecological factors and physiological toleration. Ecology 15:416-439.

_________ 1961. Mounds of the ant Formica ulkei at the Edwin S. George Reserve, Livingston County, Michigan. Ecology 42:202-205.

_________ 1966. Flights of the ant Aphaenogaster treatae. J. Kan. Entomol. Soc. 39:67-77.

Taussig, W. H. 1962. An ecological study of Formica neorufibarbis gelida Wheeler in the alpine tundra of Colorado. Master's thesis. University of Colorado. 72 pp.

Weber, N. A. 1935. The biology of the thatching ant Formica rufa obscuripes Forel in North Dakota. Ecol. Mono. 5:166-206.

Wheeler, G. C. and J. Wheeler. 1963. The ants of North Dakota. University of N. Dakota Press, Grand Forks. 326 pp.

__________ 1965. Veromessor lobognathus: third note (Hymenoptera;Formicidae). J. Kan. Entomol. Soc. 38:55-61.

Wheeler, W. M. 1910. Ants, their structure, development, and behavior. Columbia University Press, New York. 663 pp.

__________ 1917. The mountain ants of western North America. Proc. Amer. Acad. Arts Sci. 52:457-569.

Wigglesworth, Vincent B. 1965. The principles of insect physiology. Methuen and Co. Ltd., London. 741 pp.

Wilson, E. O. 1955. A monographic revision of the ant genus Lasius. Bull. Mus. Comp. Zool. 113:1-199.

Wilson, E. O. and G. L. Hunt. 1966. Habitat selection by queens of two field-dwelling species of ants. Ecology 47(3):485-487.

Yasuno, M. 1965. The study of the ant population in the grassland at Mt. Hakkôda. IV. The stability of the ant population. Sci. Rep. Tôhoku Univ. Ser. IV (Biol.) 31:75-81.

__________ 1965. The study of the ant population in the grassland at Mt. Hakkôda. V. The interspecific and intraspecific relation in the formation of the ant population, with special reference to the effect of the removal of Formica truncorum yessensis. Sci. Rep. Tôhoku Univ. Ser. IV (Biol.) 31:181-194.

APPENDIX

TABLE I

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 1

Colony number	Date	Species
	June	
1	15	*Lasius (C.) umbratus aphidicola* (Walsh)
2	15	*Tapinoma sessile* (Say)
*		*Formica (N.) pallidefulva* Latreille
		Solenopsis (D.) molesta validiuscula Emery
3	15	*Lasius (C.) umbratus aphidicola* (Walsh)
4	15	*Formica (N.) pallidefulva* Latreille
5	15	*Formica (N.) pallidefulva* Latreille
6	15	*Lasius (C.) umbratus aphidicola* (Walsh)
7	15	*Formica (N.) pallidefulva* Latreille
		Tapinoma sessile (Say)
8	15	*Formica (P.) lasioides* Emery
9	15	*Formica (N.) pallidefulva* Latreille
10	15	*Formica (N.) pallidefulva* Latreille
11	15	*Camponotus (T.) vicinus* Mayr
12	16	*Formica (N.) pallidefulva* Latreille
13	16	*Formica (P.) lasioides* Emery
14	16	*Camponotus (T.) vicinus* Mayr
15	16	*Formica (N.) pallidefulva* Latreille
16	16	*Lasius (C.) umbratus aphidicola* (Walsh)
17	16	*Formica (N.) pallidefulva* Latreille
18	16	*Formica (N.) pallidefulva* Latreille
19	16	*Camponotus (T.) vicinus* Mayr
20	16	*Camponotus (T.) vicinus* Mayr
21	16	*Formica (N.) pallidefulva* Latreille
22	16	*Iridomyrmex pruinosus analis* (E. André)
23	16	*Tapinoma sessile* (Say)
24	16	*Solenopsis (D.) molesta validiuscula* Emery
25	16	*Aphaenogaster (A.) subterranea valida* Wheeler
26	16	*Aphaenogaster (A.) subterranea valida* Wheeler
27	16	*Tapinoma sessile* (Say)
28	16	*Aphaenogaster (A.) subterranea valida* Wheeler
29	16	*Aphaenogaster (A.) subterranea valida* Wheeler
30	16	*Aphaenogaster (A.) subterranea valida* Wheeler
31	16	*Lasius alienus americanus* Emery
32	16	*Tapinoma sessile* (Say)
33	16	*Formica (N.) pallidefulva* Latreille
34	16	*Lasius (C.) umbratus aphidicola* (Walsh)
		Formica (N.) pallidefulva Latreille
35	16	*Lasius niger neoniger* Emery

*When the colony number is omitted, this indicates that more than one species was found beneath the same rock.

TABLE I (Continued)

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 1

Colony number	Date	Species
	June	
36	16	Formica (P.) pallidefulva Latreille
37	16	Pheidole pilifera coloradensis Emery
38	16	Formica obscuriventris clivia Creighton
39	16	Formica (N.) pallidefulva Latreille
40	16	Solenopsis (D.) molesta validiuscula Emery
41	16	Formica (N.) pallidefulva Latreille
42	16	Lasius niger neoniger Emery
43	16	Lasius (C.) umbratus aphidicola (Walsh)
	July	
44	6	Formica (N.) pallidefulva Latreille
45	6	Formica (N.) pallidefulva Latreille
46	6	Camponotus (T.) vicinus Mayr
47	6	Camponotus (T.) vicinus Mayr
48	6	Aphaenogaster (A.) subterranea valida Wheeler
49	6	Formica (N.) pallidefulva Latreille
50	6	Lasius (A.) claviger coloradensis Wheeler
51	6	Lasius alienus americanus Emery
52	6	Aphaenogaster (A.) subterranea valida Wheeler
53	6	Formica (N.) pallidefulva Latreille
54	6	Lasius alienus americanus Emery
55	6	Aphaenogaster (A.) subterranea valida Wheeler
56	6	Formica (N.) pallidefulva Latreille
57	6	Formica (N.) pallidefulva Latreille
58	6	Formica (N.) pallidefulva Latreille
59	6	Formica (N.) pallidefulva Latreille
60	6	Formica (N.) pallidefulva Latreille
61	6	Formica (N.) pallidefulva Latreille
62	6	Formica (N.) pallidefulva Latreille
63	7	Iridomyrmex pruinosus analis (E. André)
64	7	Lasius alienus americanus Emery
65	7	Tapinoma sessile (Say)
66	7	Formica (N.) pallidefulva Latreille
67	7	Formica (N.) pallidefulva Latreille
68	7	Solenopsis (D.) molesta validiuscula Emery
69	7	Formica (N.) pallidefulva Latreille
70	7	Solenopsis (D.) molesta validiuscula Emery
71	7	Myrmica schencki emeryana Forel
72	7	Camponotus (T.) vicinus Mayr
73	7	Lasius alienus americanus Emery
74	7	Camponotus (T.) vicinus Mayr
75	7	Solenopsis (D.) molesta validiuscula Emery
76	7	Solenopsis (D.) molesta validiuscula Emery
77	7	Formica (N.) pallidefulva Latreille
78	7	Formica (N.) pallidefulva Latreille

TABLE II

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 2

Colony number	Date	Species
	June	
1	21	*Leptothorax rugatulus* Emery
2	21	*Crematogaster lineolata* (Say)
3	21	*Crematogaster lineolata* (Say)
4	21	*Formica (N.) pallidefulva nitidiventris* Emery
5	21	*Crematogaster lineolata* (Say)
6	21	*Camponotus (T.) vicinus* Mayr
7	21	*Aphaenogaster (A.) subterranea valida* Wheeler
8	21	*Aphaenogaster (A.) subterranea valida* Wheeler
9	21	*Aphaenogaster (A.) subterranea valida* Wheeler
10	21	*Aphaenogaster (A.) subterranea valida* Wheeler
11	21	*Aphaenogaster (A.) subterranea valida* Wheeler
12	21	*Lasius niger neoniger* Emery
13	21	*Aphaenogaster (A.) subterranea valida* Wheeler
14	21	*Aphaenogaster (A.) subterranea valida* Wheeler
15	21	*Camponatus (T.) vicinus* Mayr
16	21	*Solenopsis (D.) molesta validiuscula* Emery
17	21	*Formica (N.) pallidefulva* Latreille
18	21	*Lasius (C.) brevicornis microps* Wheeler
19	21	*Formica (N.) pallidefulva* Latreille
20	21	*Formica (N.) pallidefulva* Latreille
21	21	*Tapinoma sessile* (Say)
22	21	*Tapinoma sessile* (Say)
23	22	*Aphaenogaster (A.) subterranea valida* Wheeler
24	22	*Aphaenogaster (A.) subterranea valida* Wheeler
25	22	*Solenopsis (D.) molesta validiuscula* Emery
26	22	*Aphaenogaster (A.) subterranea valida* Wheeler
27	22	*Formica fusca* Linnaeus
28	22	*Tapinoma sessile* (Say)
29	22	*Aphaenogaster (A.) subterranea valida* Wheeler
30	23	*Tapinoma sessile* (Say)
*		*Aphaenogaster (A.) subterranea valida* Wheeler
31	23	*Aphaenogaster (A.) subterranea valida* Wheeler
32	23	*Lasius (C.) umbratus aphidicula* (Walsh)
33	23	*Formica fusca* Linnaeus
34	23	*Lasius (C.) brevicornis microps* Wheeler
35	23	*Liometopum occidentale luctuosum* Wheeler
36	23	*Lasius niger neoniger* Emery
37	23	*Lasius niger neoniger* Emery

*When the colony number is omitted, this indicates that more than one species was found beneath the same rock.

TABLE II (Continued)

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 2

Colony number	Date	Species
	June	
38	23	Lasius (C.) brevicornis microps Wheeler
39	23	Lasius niger neoniger Emery
40	23	Camponotus (T.) vicinus Mayr
41	23	Lasius (A.) latipes (Walsh)
		Camponotus (T.) vicinus Mayr
42	23	Lasius niger neoniger Emery
43	23	Aphaenogaster (A.) subterranea valida Wheeler
44	23	Lasius niger neoniger Emery
45	23	Lasius niger sitkaensis Pergande
46	23	Lasius (A.) latipes (Walsh)
47	23	Camponotus (T.) vicinus Mayr
48	23	Lasius niger neoniger Emery
49	23	Aphaenogaster (A.) subterranea valida Wheeler
50	23	Lasius (C.) brevicornis microps Wheeler
51	24	Aphaenogaster (A.) subterranea valida Wheeler
52	24	Tapinoma sessile (Say)
53	24	Liometopum occidentale luctuosum Wheeler
54	24	Tapinoma sessile (Say)
55	24	Aphaenogaster (A.) subterranea valida Wheeler
56	24	Liometopum occidentale luctuosum Wheeler
57	24	Liometopum occidentale luctuosum Wheeler
58	24	Crematogaster lineolata (Say)
59	24	Crematogaster lineolata emeryana Creighton
60	24	Camponotus (T.) vicinus Mayr
61	24	Aphaenogaster (A.) subterranea valida Wheeler
62	24	Aphaenogaster (A.) subterranea valida Wheeler
63	24	Aphaenogaster (A.) subterranea valida Wheeler
64	24	Camponotus (T.) vicinus Mayr
65	24	Aphaenogaster (A.) subterranea valida Wheeler
66	24	Aphaenogaster (A.) subterranea valida Wheeler
67	24	Aphaenogaster (A.) subterranea valida Wheeler
68	24	Lasius niger neoniger Emery
69	24	Lasius niger sitkaensis Pergande
70	24	Aphaenogaster (A.) subterranea valida Wheeler
71	24	Aphaenogaster (A.) subterranea valida Wheeler
72	24	Camponotus (T.) vicinus Mayr
73	24	Aphaenogaster (A.) subterranea valida Wheeler
74	24	Lasius niger sitkaensis Pergande
75	24	Lasius niger neoniger Emery
76	24	Aphaenogaster (A.) subterranea valida Wheeler

TABLE II (Continued)

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 2

Colony number	Date	Species
	June	
77	24	*Lasius niger neoniger* Emery
		Lasius (C.) brevicornis microps Wheeler
78	24	*Lasius (C.) brevicornis microps* Wheeler
79	24	*Lasius (C.) brevicornis microps* Wheeler
80	24	*Lasius (C.) brevicornis microps* Wheeler
81	24	*Lasius niger neoniger* Emery
82	25	*Lasius niger sitkaensis* Pergande
83	25	*Lasius (C.) umbratus aphidicola* (Walsh)
84	25	*Lasius niger neoniger* Emery
85	25	*Lasius niger neoniger* Emery
86	25	*Lasius niger neoniger* Emery
87	25	*Lasius niger neoniger* Emery
88	25	*Lasius niger neoniger* Emery
89	25	*Lasius niger neoniger* Emery
90	25	*Aphaenogaster (A.) subterranea valida* Wheeler
91	25	*Formica fusca* Linnaeus
92	25	*Tapinoma sessile* (Say)
93	28	*Aphaenogaster (A.) subterranea valida* Wheeler
94	28	*Lasius (C.) brevicornis microps* Wheeler
95	28	*Tapinoma sessile* (Say)
96	28	*Aphaenogaster (A.) subterranea valida* Wheeler
97	28	*Lasius (A.) latipes* (Walsh)
98	28	*Lasius (C.) brevicornis microps* Wheeler
99	28	*Liometopum occidentale luctuosum* Wheeler
100	28	*Tapinoma sessile* (Say)
101	28	*Lasius niger neoniger* Emery
102	28	*Formica fusca* Linnaeus
103	28	*Aphaenogaster (A.) subterranea valida* Wheeler
104	28	*Lasius niger neoniger* Emery
105	28	*Aphaenogaster (A.) subterranea valida* Wheeler
106	28	*Tapinoma sessile* (Say)
		Lasius (C.) brevicornis microps Wheeler
107	28	*Aphaenogaster (A.) subterranea valida* Wheeler
108	28	*Lasius niger neoniger* Emery
109	28	*Lasius niger neoniger* Emery
110	28	*Aphaenogaster (A.) subterranea valida* Wheeler
111	29	*Aphaenogaster (A.) subterranea valida* Wheeler
112	29	*Formica fusca* Linnaeus
113	29	*Formica fusca* Linnaeus
114	29	*Lasius (C.) brevicornis microps* Wheeler

TABLE II (Continued)

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 2

Colony number	Date	Species
	June	
115	29	Tapinoma sessile (Say)
116	29	Lasius (C.) brevicornis microps Wheeler
117	29	Lasius (C.) brevicornis microps Wheeler
118	29	Lasius (C.) brevicornis microps Wheeler
119	29	Lasius (C.) brevicornis microps Wheeler
120	29	Formica fusca Linnaeus
		Lasius (C.) brevicornis microps Wheeler
121	29	Aphaenogaster (A.) subterranea valida Wheeler
122	29	Lasius (C.) brevicornis microps Wheeler
123	29	Lasius (C.) brevicornis microps Wheeler
124	29	Lasius niger neoniger Emery
125	29	Formica (P.) lasioides Emery
126	30	Aphaenogaster (A.) subterranea valida Wheeler
127	30	Leptothorax rugatulus Emery
128	30	Lasius (A.) latipes (Walsh)
129	30	Lasius niger neoniger Emery
130	30	Lasius niger neoniger Emery
131	30	Lasius niger neoniger Emery
132	30	Aphaenogaster (A.) subterranea valida Wheeler
133	30	Formica fusca Linnaeus
134	30	Formica fusca Linnaeus
135	30	Lasius niger neoniger Emery
136	30	Lasius niger neoniger Emery
137	30	Aphaenogaster (A.) subterranea valida Wheeler
138	30	Aphaenogaster (A.) subterranea valida Wheeler
139	30	Lasius (C.) brevicornis microps Wheeler
140	30	Aphaenogaster (A.) subterranea valida Wheeler
141	30	Lasius niger neoniger Emery
142	30	Lasius niger neoniger Emery
143	30	Lasius niger neoniger Emery
144	30	Lasius (C.) brevicornis microps Wheeler
	July	
145	1	Lasius (C.) brevicornis microps Wheeler
146	1	Lasius (C.) brevicornis microps Wheeler
147	1	Lasius niger neoniger Emery
148	1	Leptothorax rugatulus Emery
149	1	Leptothorax rugatulus Emery
150	1	Leptothorax rugatulus Emery
151	1	Lasius niger neoniger Emery
152	1	Lasius niger neoniger Emery

TABLE II (Continued)

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 2

Colony number	Date	Species
	July	
153	1	Lasius niger neoniger Emery
154	1	Lasius niger neoniger Emery
155	1	Lasius niger neoniger Emery
156	1	Lasius niger neoniger Emery
157	1	Lasius niger neoniger Emery
158	1	Lasius niger neoniger Emery
159	1	Lasius niger neoniger Emery
160	1	Lasius niger neoniger Emery
161	1	Lasius niger neoniger Emery
162	1	Lasius niger neoniger Emery
163	1	Lasius (C.) brevicornis microps Wheeler
164	1	Lasius (C.) brevicornis microps Wheeler
165	1	Camponotus (T.) vicinus Mayr
166	1	Camponotus (T.) vicinus Mayr
167	1	Camponotus (T.) vicinus Mayr
168	1	Leptothorax rugatulus Emery
169	1	Camponotus (T.) vicinus Mayr
170	2	Liometopum occidentale luctuosum Wheeler
171	2	Camponotus (T.) vicinus Mayr
172	2	Tapinoma sessile (Say)
173	2	Aphaenogaster (A.) subterranea valida Wheeler
174	2	Tapinoma sessile (Say)
175	2	Tapinoma sessile (Say)
176	2	Formica (N.) pallidefulva nitidiventris Emery
177	2	Tapinoma sessile (Say)
		Aphaenogaster (A.) subterranea valida Wheeler
178	2	Aphaenogaster (A.) subterranea valida Wheeler
179	2	Tapinoma sessile (Say)
180	2	Crematogaster lineolata (Say)
181	2	Tapinoma sessile (Say)
182	2	Liometopum occidentale luctuosum Wheeler
183	2	Lasius niger neoniger Emery
184	2	Lasius (C.) umbratus aphidicola (Walsh)
185	2	Aphaenogaster (A.) subterranea valida Wheeler
186	2	Aphaenogaster (A.) subterranea valida Wheeler
187	2	Tapinoma sessile (Say)
188	2	Formica (N.) pallidefulva Latreille
189	2	Aphaenogaster (A.) subterranea valida Wheeler

TABLE II (Continued)

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 2

Colony number	Date	Species
	July	
190	2	Aphaenogaster (A.) subterranea valida Wheeler
191	2	Aphaenogaster (A.) subterranea valida Wheeler
192	2	Aphaenogaster (A.) subterranea valida Wheeler
193	2	Aphaenogaster (A.) subterranea valida Wheeler
194	2	Tapinoma sessile (Say)
195	2	Camponotus (T.) vicinus Mayr
196	2	Aphaenogaster (A.) subterranea valida Wheeler
197	2	Formica (N.) pallidefulva Latreille
198	2	Camponotus (T.) vicinus Mayr
199	2	Formica (N.) pallidefulva Latreille

TABLE III

LIST OF ANT SPECIES FOUND IN 1965
IN QUADRAT 3

Colony number	Date	Species
	July	
1	6	Formica obscuripes Forel
2	6	Lasius alienus americanus Emery
3	6	Lasius alienus americanus Emery
4	6	Lasius (C.) umbratus aphidicola (Walsh)
5	6	Lasius (C.) umbratus aphidicola (Walsh)
6	6	Solenopsis (D.) molesta validiuscula Emery
7	6	Solenopsis (D.) molesta validiuscula Emery
8	6	Lasius (C.) umbratus aphidicola (Walsh)
9	6	Solenopsis (D.) molesta validiuscula Emery
10	6	Solenopsis (D.) molesta validiuscula Emery
11	6	Lasius (C.) umbratus aphidicola (Walsh)
12	6	Lasius (C.) umbratus aphidicola (Walsh)
13	6	Formica fusca argentea Wheeler
14	6	Lasius (C.) umbratus aphidicola (Walsh)
15	6	Lasius (C.) umbratus aphidicola (Walsh)
16	6	Lasius (A.) latipes (Walsh)
17	6	Lasius (C.) umbratus aphidicola (Walsh)
18	6	Lasius alienus americanus Emery
19	6	Solenopsis (D.) molesta validiuscula Emery
20	6	Lasius alienus americanus Emery
21	6	Solenopsis (D.) molesta validiuscula Emery
22	6	Solenopsis (D.) molesta validiuscula Emery
23	6	Lasius alienus americanus Emery
24	6	Lasius (A.) latipes (Walsh)
25	6	Lasius (C.) umbratus aphidicola (Walsh)
26	7	Lasius (C.) umbratus aphidicola (Walsh)
27	7	Lasius alienus americanus Emery
28	7	Tapinoma sessile (Say)
29	7	Tapinoma sessile (Say)
30	7	Lasius (C.) umbratus aphidicola (Walsh)
31	7	Lasius (A.) latipes (Walsh)
32	7	Lasius (C.) umbratus aphidicola (Walsh)
33	7	Formica (N.) pallidefulva nitidiventris Emery
34	7	Solenopsis (D.) molesta validiuscula Emery

TABLE IV

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 1

Colony number	Date	Species
	Aug.	
1	1	Lasius (C.) umbratus aphidicola (Walsh)
2	1	—
3	1	—
4	1	—
5	1	—
6	1	—
7	1	—
8	1	—
9	1	Formica (N.) pallidefulva Latreille
10	1	—
11	1	Camponotus (T.) vicinus Mayr
12	1	—
13	1	Formica (P.) lasioides Emery
14	1	Camponotus (T.) vicinus Mayr
15	1	Formica (N.) pallidefulva Latreille
16	1	Formica (N.) pallidefulva Latreille
17	1	—
18	1	Formica (N.) pallidefulva Latreille
19	1	Camponotus (T.) vicinus Mayr
20	1	Camponotus (T.) vicinus Mayr
21	1	Formica (N.) pallidefulva Latreille
22	1	Iridomyrmex pruinosus analis (E. André)
23	1	—
24	1	—
25	1	—
26	1	—
27	1	—
28	1	Aphaenogaster (A.) subterranea valida Wheeler
29	2	Aphaenogaster (A.) subterranea valida Wheeler
30	2	Formica (N.) pallidefulva Latreille
31	2	—
32	2	—
33	2	Formica (N.) pallidefulva Latreille
34	2	—
35	2	—
36	2	—
37	2	—
38	2	—
39	2	—
40	2	—

TABLE IV (Continued)

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 1

Colony number	Date	Species
	Aug.	
41	2	—
42	2	Formica (N.) pallidefulva Latreille
43	2	—
44	2	Formica (N.) pallidefulva Latreille
45	2	Formica (N.) pallidefulva Latreille
46	2	Camponotus (T.) vicinus Mayr
47	2	Camponotus (T.) vicinus Mayr
48	2	Aphaenogaster (A.) subterranea valida Wheeler
49	2	—
50	2	—
51	3	Formica (N.) pallidefulva Latreille
52	3	Formica (N.) pallidefulva Latreille
53	3	—
54	3	Lasius alienus americanus Emery
55	3	Aphaenogaster (A.) subterranea valida Wheeler
56	3	—
57	3	—
58	3	—
59	3	Formica (N.) pallidefulva Latreille
60	3	Formica (N.) pallidefulva Latreille
61	3	—
62	3	Formica (N.) pallidefulva Latreille
63	3	Iridomyrmex pruinosus analis (E. André)
64	3	Lasius alienus americanus Emery
65	3	—
66	3	—
67	3	Solenopsis (D.) molesta validiuscula Emery
68	3	—
69	3	Formica (N.) pallidefulva Latreille
70	3	—
71	3	Myrmica schencki emeryana Forel
72	4	Camponotus (T.) vicinus Mayr
73	4	—
74	4	Camponotus (T.) vicinus Mayr
75	4	—
76	4	—
77	4	—
78	4	—

TABLE IV (Continued)

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 1

Colony number	Date	Species
	Aug.	New Colonies for 1966
79	4	Formica (N.) pallidefulva Latreille
80	4	Aphaenogaster (A.) subterranea valida Wheeler
81	4	Aphaenogaster (A.) subterranea valida Wheeler
82	4	Formica (N.) pallidefulva Latreille
83	4	Myrmica schencki emeryana Forel
		Lasius niger neoniger Emery
84	4	Formica (N.) pallidefulva Latreille
85	4	Formica (N.) pallidefulva Latreille
86	4	Myrmica schencki emeryana Forel
		Formica (N.) pallidefulva Latreille
87	4	Formica (N.) pallidefulva Latreille
88	4	Lasius alienus americanus Emery
89	5	Camponotus (T.) vicinus Mayr
90	5	Pheidole pilifera coloradensis Emery
91	5	Tapinoma sessile (Say)

TABLE V

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
1	6	—
2	6	—
3	6	Crematogaster lineolata (Say)
4	6	—
5	6	—
6	6	—
7	6	Aphaenogaster (A.) subterranea valida Wheeler
8	6	—
9	6	—
10	6	Aphaenogaster (A.) subterranea valida Wheeler
11	6	Aphaenogaster (A.) subterranea valida Wheeler
12	6	—
13	6	—
14	6	—
15	6	—
16	6	—
17	6	—
18	7	Lasius (C.) brevicornis microps Wheeler
19	7	—
20	7	Formica (N.) pallidefulva Latreille
21	7	Tapinoma sessile (Say)
22	7	Lasius (C.) brevicornis microps Wheeler
23	7	Camponotus (T.) vicinus Mayr
24	7	—
25	7	—
26	7	Camponotus (T.) vicinus Mayr
27	7	—
28	7	Leptothorax rugatulus Emery
29	7	—
30	7	Liometopum occidentale luctuosum Wheeler
31	7	—
32	7	—
33	8	Formica fusca Linnaeus
34	8	—
35	8	—
36	8	—
37	8	Lasius (C.) brevicornis microps Wheeler
38	8	—
39	8	—

TABLE V (Continued)

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
40	8	*Aphaenogaster* (*A.*) *subterranea* *valida* Wheeler
41	8	—
42	8	—
43	8	—
44	8	—
45	8	—
46	8	—
47	8	—
48	8	—
49	8	*Aphaenogaster* (*A.*) *subterranea* *valida* Wheeler
50	8	—
51	8	—
52	8	—
53	9	*Liometopum* *occidentale* *luctuosum* Wheeler
54	9	*Camponotus* (*T.*) *vicinus* Mayr
55	9	*Aphaenogaster* (*A.*) *subterranea* *valida* Wheeler
56	9	*Liometopum* *occidentale* *luctuosum* Wheeler
57	9	—
58	9	*Camponotus* (*T.*) *vicinus* Mayr
59	9	—
60	9	*Camponotus* (*T.*) *vicinus* Mayr
61	9	*Camponotus* (*T.*) *vicinus* Mayr
62	9	*Aphaenogaster* (*A.*) *subterranea* *valida* Wheeler
63	9	—
64	9	*Formica* (*N.*) *pallidefulva* Latreille
65	9	*Aphaenogaster* (*A.*) *subterranea* *valida* Wheeler
66	9	*Aphaenogaster* (*A.*) *subterranea* *valida* Wheeler
67	9	—
68	9	*Lasius* *niger* *neoniger* Emery
69	9	—
70	9	—
71	9	*Aphaenogaster* (*A.*) *subterranea* *valida* Wheeler
72	10	*Camponotus* (*T.*) *vicinus* Mayr
73	10	—
74	10	—
75	10	*Lasius* *niger* *neoniger* Emery
76	10	—
77	10	—
78	10	—

TABLE V (Continued)

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
79	10	Lasius (C.) brevicornis microps Wheeler
80	10	Lasius (C.) brevicornis microps Wheeler
81	10	—
82	10	Lasius niger sitkaensis Pergande
83	10	—
84	10	—
85	10	Leptothorax rugatulus Emery
86	10	
87	10	Lasius niger neoniger Emery
88	10	—
89	10	—
90	10	—
91	11	Formica fusca Linnaeus
92	11	—
93	11	Aphaenogaster (A.) subterranea valida Wheeler
94	11	Lasius (C.) brevicornis microps Wheeler
95	11	—
96	11	Aphaenogaster (A.) subterranea valida Wheeler
97	11	Lasius (A.) latipes (Walsh)
98	11	—
99	11	—
100	11	Lasius (C.) brevicornis microps Wheeler
101	11	Lasius niger neoniger Emery
102	11	—
103	11	—
104	11	Lasius niger neoniger Emery
105	11	—
106	11	Lasius (C.) brevicornis microps Wheeler
107	11	Aphaenogaster (A.) subterranea valida Wheeler
108	11	—
109	12	Lasius niger neoniger Emery
110	12	Aphaenogaster (A.) subterranea valida Wheeler
111	12	—
112	12	—
113	12	—
114	12	Aphaenogaster (A.) subterranea valida Wheeler
115	12	—
116	12	Lasius (C.) brevicornis microps Wheeler
117	12	Lasius (C.) brevicornis microps Wheeler

TABLE V (Continued)

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
118	12	Lasius (C.) brevicornis microps Wheeler
119	12	Leptothorax rugatulus Emery
		Lasius (C.) brevicornis microps Wheeler
120	12	Lasius (C.) brevicornis microps Wheeler
121	12	—
122	12	Lasius (C.) brevicornis microps Wheeler
123	12	Lasius (C.) brevicornis microps Wheeler
124	12	—
125	12	Formica (P.) lasioides Emery
126	12	Aphaenogaster (A.) subterranea valida Wheeler
127	13	Leptothorax rugatulus Emery
128	13	—
129	13	—
130	13	—
131	13	—
132	13	—
133	13	—
134	13	—
135	13	—
136	13	—
137	13	—
138	13	—
139	13	—
140	13	Aphaenogaster (A.) subterranea valida Wheeler
141	13	Lasius niger neoniger Emery
142	13	—
143	13	—
144	13	—
145	13	Lasius (C.) brevicornis microps Wheeler
146	14	Lasius (C.) brevicornis microps Wheeler
147	14	Lasius niger neoniger Emery
148	14	—
149	14	Lasius (C.) brevicornis microps Wheeler
150	14	—
151	14	—
152	14	—
153	14	Lasius niger neoniger Emery
154	14	—
155	14	Lasius niger neoniger Emery

TABLE V (Continued)

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
156	14	Lasius niger neoniger Emery
157	14	Lasius niger neoniger Emery
158	14	—
159	14	—
160	14	Lasius niger neoniger Emery
161	14	Lasius niger neoniger Emery
162	14	Lasius niger neoniger Emery
163	14	Aphaenogaster (A.) subterranea valida Wheeler
164	14	Aphaenogaster (A.) subterranea valida Wheeler
165	14	Camponotus (T.) vicinus Mayr
166	14	—
167	14	—
168	15	Leptothorax rugatulus Emery
169	15	Camponotus (T.) vicinus Mayr
170	15	—
171	15	Formica fusca Linnaeus
172	15	—
173	15	—
174	15	—
175	15	—
176	15	—
177	15	Aphaenogaster (A.) subterranea valida Wheeler
178	15	—
179	15	Tapinoma sessile (Say)
180	15	—
181	15	—
182	15	—
183	15	—
184	15	Lasius (C.) umbratus aphidicola (Walsh)
185	16	Aphaenogaster (A.) subterranea valida Wheeler
186	16	—
187	16	—
188	16	—
189	16	—
190	16	Aphaenogaster (A.) subterranea valida Wheeler
191	16	Aphaenogaster (A.) subterranea valida Wheeler
192	16	Aphaenogaster (A.) subterranea valida Wheeler
193	16	—
194	16	—

TABLE V (Continued)

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
195	16	—
196	16	—
197	16	Aphaenogaster (A.) subterranea valida Wheeler
198	16	Camponotus (T.) vicinus Mayr
199	16	Formica (N.) pallidefulva Latreille
		New Colonies for 1966
200	16	Aphaenogaster (A.) subterranea valida Wheeler
201	16	Aphaenogaster (A.) subterranea valida Wheeler
202	16	Camponotus (T.) vicinus Mayr
203	16	Formica fusca Linnaeus
204	16	Aphaenogaster (A.) subterranea valida Wheeler Formica fusca Linnaeus
205	17	Aphaenogaster (A.) subterranea valida Wheeler
206	17	Tapinoma sessile (Say)
207	17	Aphaenogaster (A.) subterranea valida Wheeler
208	17	Tapinoma sessile (Say)
209	17	Aphaenogaster (A.) subterranea valida Wheeler
210	17	Lasius niger neoniger Emery
211	17	Lasius niger neoniger Emery
212	17	Aphaenogaster (A.) subterranea valida Wheeler
213	17	Aphaenogaster (A.) subterranea valida Wheeler
214	17	Tapinoma sessile (Say)
215	17	Formica (N.) pallidefulva Latreille
216	17	Aphaenogaster (A.) subterranea valida Wheeler
217	17	Camponotus (T.) vicinus Mayr
218	17	Aphaenogaster (A.) subterranea valida Wheeler
219	17	Aphaenogaster (A.) subterranea valida Wheeler
220	17	Lasius niger neoniger Emery
221	18	Aphaenogaster (A.) subterranea valida Wheeler
222	18	Lasius (C.) brevicornis microps Wheeler
223	18	Lasius niger sitkaensis Pergande
224	18	Lasius niger neoniger Emery
225	18	Aphaenogaster (A.) subterranea valida Wheeler
226	18	Lasius niger neoniger Emery
227	18	Lasius niger neoniger Emery
228	18	Aphaenogaster (A.) subterranea valida Wheeler
229	18	Lasius (C.) brevicornis microps Wheeler

TABLE VI

LIST OF ANT SPECIES FOUND IN 1966
IN QUADRAT 3

Colony number	Date	Species
	Aug.	
1	20	Formica obscuripes Forel
2	20	Solenopsis (D.) molesta validiuscula Emery
3	20	—
4	20	—
5	20	—
6	20	—
7	20	Solenopsis (D.) molesta validiuscula Emery
8	20	Lasius (C.) umbratus aphidicola (Walsh)
9	20	Solenopsis (D.) molesta validiuscula Emery
10	20	—
11	20	Lasius (C.) umbratus aphidicola (Walsh)
12	20	—
13	20	—
14	20	Lasius (A.) latipes (Walsh)
15	20	Lasius (A.) latipes (Walsh)
16	20	Formica obscuripes Forel
17	20	Lasius (C.) umbratus aphidicola (Walsh)
18	20	Lasius alienus americanus Emery
19	20	—
20	20	—
21	20	—
22	20	Solenopsis (D.) molesta validiuscula Emery
23	20	—
24	20	—
25	20	—
26	21	Tapinoma sessile (Say)
27	21	—
28	21	—
29	21	—
30	21	Lasius (C.) umbratus aphidicola (Walsh)
31	21	Solenopsis (D.) molesta validiuscula Emery
32	21	—
33	21	Formica (N.) pallidefulva nitidiventris Emery
34	21	Solenopsis (D.) molesta validiuscula Emery
		New Colonies for 1966
35	21	Lasius alienus americanus Emery
36	21	Lasius (C.) umbratus aphidicola (Walsh)
37	21	Formica (N.) pallidefulva nitidiventris Emery
38	21	Solenopsis (D.) molesta validiuscula Emery
39	21	Tapinoma sessile (Say)
40	21	Solenopsis (D.) molesta validiuscula Emery
41	21	Lasius (C.) umbratus aphidicola (Walsh)
		Aphaenogaster (A.) subterranea valida Wheeler

TABLE VII

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 1

Colony number	Date	Species
	July	
1	31	Lasius (C.) umbratus aphidicola (Walsh)
2	31	—
3	31	—
4	31	Formica (N.) pallidefulva Latreille
5	31	—
6	31	—
7	31	—
8	31	—
9	31	Formica (N.) pallidefulva Latreille
10	31	Formica (N.) pallidefulva Latreille
11	31	Camponotus (T.) vicinus Mayr
12	31	—
13	31	Formica (P.) lasioides Emery
14	31	Camponotus (T.) vicinus Mayr
15	31	Formica (N.) pallidefulva Latreille
16	Aug.	
16	1	Solenopsis (D.) molesta validiuscula Emery
17	1	—
18	1	—
19	1	Camponotus (T.) vicinus Mayr
20	1	Camponotus (T.) vicinus Mayr
21	1	Formica (N.) pallidefulva Latreille
22	1	Iridomyrmex pruinosus analis (E. Andre)
23	1	—
24	1	—
25	1	—
26	1	—
27	1	—
28	1	—
29	1	Aphaenogaster (A.) subterranea valida Wheeler
30	2	Aphaenogaster (A.) subterranea valida Wheeler
31	2	Lasius alienus americanus Emery
32	2	—
33	2	—
34	2	—
35	2	—
36	2	—
37	2	—
38	2	Formica obscuriventris clivia Creighton
39	2	—
40	2	Solenopsis (D.) molesta validiuscula Emery

TABLE VII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 1

Colony number	Date	Species
	Aug.	
41	2	—
42	2	—
43	2	—
44	2	Solenopsis (D.) molesta validiuscula Emery Formica (N.) pallidefulva Latreille
45	2	—
46	2	Camponotus (T.) vicinus Mayr
47	3	Camponotus (T.) vicinus Mayr
48	3	Aphaenogaster (A.) subterranea valida Wheeler
49	3	Aphaenogaster (A.) subterranea valida Wheeler
50	3	Lasius (C.) umbratus aphidicola (Walsh)
51	3	Formica (N.) pallidefulva Latreille
52	3	Formica (N.) pallidefulva Latreille
53	3	Formica (N.) pallidefulva Latreille
54	3	—
55	3	—
56	3	—
57	3	—
58	3	—
59	3	—
60	3	Formica (N.) pallidefulva Latreille
61	3	—
62	3	—
63	3	Formica (N.) pallidefulva Latreille
64	3	Lasius (A.) latipes (Walsh)
65	3	—
66	3	—
67	3	—
68	3	Solenopsis (D.) molesta validiuscula Emery
69	3	—
70	3	Solenopsis (D.) molesta validiuscula Emery
71	3	—
72	3	Camponotus (T.) vicinus Mayr
73	3	—
74	3	Camponotus (T.) vicinus Mayr
75	3	—
76	3	—
77	3	—
78	3	—
79	3	—

TABLE VII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 1

Colony number	Date	Species
	Aug.	
80	4	Aphaenogaster (A.) subterranea valida Wheeler
81	4	—
82	4	—
83	4	—
84	4	—
85	4	—
86	4	Formica (N.) pallidefulva Latreille
87	4	Formica (N.) pallidefulva Latreille
88	4	—
89	4	—
90	4	Pheidole pilifera coloradensis Emery
91	4	—
		New Colonies for 1967
92	4	Formica (N.) pallidefulva Latreille
93	4	Formica (N.) pallidefulva Latreille
94	4	Tapinoma sessile (Say)
95	4	Solenopsis (D.) molesta validiuscula Emery
96	4	Solenopsis (D.) molesta validiuscula Emery
97	4	Solenopsis (D.) molesta validiuscula Emery
98	4	Formica (N.) pallidefulva Latreille
99	4	Formica (N.) pallidefulva Latreille
100	4	Formica (N.) pallidefulva Latreille Solenopsis (D.) molesta validiuscula Emery
101	4	Formica (N.) pallidefulva Latreille
102	4	Solenopsis (D.) molesta validiuscula Emery
103	4	Formica (N.) pallidefulva Latreille
104	4	Camponotus (T.) vicinus Mayr
105	4	Lasius alienus americanus Emery
106	5	Formica (N.) pallidefulva Latreille
107	5	Crematogaster lineolata (Say)
108	5	Aphaenogaster (A.) subterranea valida Wheeler

TABLE VIII

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
1	9	Crematogaster lineolata (Say)
2	9	—
3	9	Crematogaster lineolata (Say)
4	9	—
5	9	—
6	9	—
7	9	Aphaenogaster (A.) subterranea valida Wheeler
8	9	—
9	9	—
10	9	Aphaenogaster (A.) subterranea valida Wheeler
11	9	—
12	9	—
13	9	—
14	9	Aphaenogaster (A.) subterranea valida Wheeler
15	9	—
16	9	—
17	9	Tapinoma sessile (Say) Formica (P.) limata Wheeler
18	9	Lasius (C.) brevicornis microps Wheeler Aphaenogaster subterranea valida Wheeler
19	9	Solenopsis (D.) molesta validiuscula Emery Formica (N.) pallidefulva Latreille
20	9	Solenopsis (D.) molesta validiuscula Emery
21	9	Solenopsis (D.) molesta validiuscula Emery
22	9	Solenopsis (D.) molesta validiuscula Emery
23	9	Camponotus (T.) vicinus Mayr
24	9	—
25	9	—
26	9	Camponotus (T.) vicinus Mayr
27	9	—
28	9	Leptothorax rugatulus Emery
29	9	—
30	9	—
31	9	—
32	9	—
33	9	—
34	9	—
35	9	—
36	10	Aphaenogaster (A.) subterranea valida Wheeler

TABLE VIII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
37	10	—
38	10	—
39	10	—
40	10	—
41	10	—
42	10	—
43	10	—
44	10	—
45	10	—
46	10	*Lasius niger neoniger* Emery
47	10	—
48	10	*Leptothorax rugatulus* Emery
49	10	—
50	10	—
51	10	*Tapinoma sessile* (Say)
52	10	—
53	10	—
54	10	*Camponotus* (*T.*) *vicinus* Mayr
55	10	*Aphaenogaster* (*A.*) *subterranea valida* Wheeler
56	10	*Liometopum occidentale luctuosum* Wheeler
57	10	—
58	10	*Crematogaster lineolata* (Say)
59	10	—
60	10	—
61	10	—
62	10	—
63	10	—
64	10	—
65	10	*Aphaenogaster* (*A.*) *subterranea valida* Wheeler
66	10	*Tapinoma sessile* (Say)
67	10	*Aphaenogaster* (*A.*) *subterranea valida* Wheeler
68	10	—
69	10	—
70	10	—
71	10	—
72	11	*Camponotus* (*T.*) *vicinus* Mayr
73	11	—
74	11	—
75	11	—
76	11	—
77	11	—

TABLE VIII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
78	11	Aphaenogaster (A.) subterranea valida Wheeler
		Lasius (C.) brevicornis microps Wheeler
79	11	Lasius (C.) brevicornis microps Wheeler
80	11	—
81	11	—
82	11	Lasius niger sitkaensis Pergande
83	11	Lasius (C.) umbratus aphidicola (Walsh)
84	11	—
85	11	Leptothorax rugatulus Emery
86	11	Leptothorax rugatulus Emery
87	11	Lasius niger neoniger Emery
88	11	—
89	11	—
90	11	—
91	11	Formica fusca Linnaeus
92	11	—
93	11	Aphaenogaster (A.) subterranea valida Wheeler
94	11	—
95	11	Tapinoma sessile (Say)
96	11	Aphaenogaster (A.) subterranea valida Wheeler
97	11	Lasius (A.) latipes (Walsh)
98	11	—
99	11	—
100	11	Lasius (C.) brevicornis microps Wheeler
101	11	Lasius niger neoniger Emery
102	11	—
103	11	—
104	11	Lasius niger neoniger Emery
105	11	—
106	11	—
107	12	Aphaenogaster (A.) subterranea valida Wheeler
108	12	—
109	12	Lasius niger neoniger Emery
110	12	Aphaenogaster (A.) subterranea valida Wheeler
111	12	—
112	12	—
113	12	—
114	12	Aphaenogaster (A.) subterranea valida Wheeler
115	12	—

TABLE VIII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
116	12	Lasius (C.) brevicornis microps Wheeler
117	12	Lasius (C.) brevicornis microps Wheeler
118	12	Lasius (C.) brevicornis microps Wheeler
119	12	Lasius (C.) brevicornis microps Wheeler
120	12	Lasius (C.) brevicornis microps Wheeler
121	12	—
122	12	—
123	12	Lasius (C.) brevicornis microps Wheeler
124	12	—
125	12	Lasius (C.) umbratus aphidicola (Walsh)
126	12	—
127	12	—
128	12	—
129	12	—
130	13	Lasius niger neoniger Emery
131	13	—
132	13	—
133	13	Formica fusca Linnaeus
134	13	—
135	13	—
136	13	—
137	13	—
138	13	—
139	13	Formica (P.) lasioides Emery
140	13	—
141	13	—
142	13	—
143	13	—
144	13	—
145	13	Lasius (C.) brevicornis microps Wheeler
146	13	Lasius (C.) brevicornis microps Wheeler
147	13	Lasius niger neoniger Emery
148	13	—
149	13	—
150	13	—
151	13	—
152	13	Leptothorax rugatulus Emery
153	14	Lasius niger neoniger Emery
154	14	Lasius niger neoniger Emery
155	14	Lasius niger neoniger Emery

TABLE VIII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
156	14	Lasius niger neoniger Emery
157	14	—
158	14	—
159	14	—
160	14	—
161	14	Lasius niger neoniger Emery
162	14	Lasius niger neoniger Emery
163	14	—
164	14	—
165	14	—
166	14	—
167	14	—
168	14	—
169	14	Camponotus (T.) vicinus Mayr
170	14	—
171	14	—
172	14	—
173	14	—
174	14	Leptothorax rugatulus Emery
175	14	—
176	14	—
177	14	—
178	14	—
179	14	Leptothorax rugatulus Emery
180	15	Aphaenogaster (A.) subterranea valida Wheeler
181	15	Formica (N.) pallidefulva Latreille
182	15	Solenopsis (D.) molesta validiuscula Emery
183	15	—
184	15	Lasius (C.) umbratus aphidicola (Walsh)
185	15	—
186	15	—
187	15	—
188	15	—
189	15	—
190	15	Aphaenogaster (A.) subterranea valida Wheeler
191	15	—
192	15	Aphaenogaster (A.) subterranea valida Wheeler
193	15	—
194	15	Crematogaster lineolata (Say)
195	15	—

TABLE VIII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
196	16	Aphaenogaster (A.) subterranea valida Wheeler
197	16	—
198	16	—
199	16	—
200	16	—
201	16	Aphaenogaster (A.) subterranea valida Wheeler
202	16	—
203	16	Formica fusca Linnaeus
204	16	Tapinoma sessile (Say)
205	16	Aphaenogaster (A.) subterranea valida Wheeler
206	16	Lasius niger neoniger Emery
207	16	—
208	16	—
209	16	Tapinoma sessile (Say)
210	16	Lasius niger neoniger Emery
211	16	Lasius niger neoniger Emery
212	16	—
213	16	—
214	16	—
215	16	—
216	16	Aphaenogaster (A.) subterranea valida Wheeler
217	16	—
218	16	Aphaenogaster (A.) subterranea valida Wheeler
219	16	Aphaenogaster (A.) subterranea valida Wheeler
220	16	Lasius niger neoniger Emery
221	16	Aphaenogaster (A.) subterranea valida Wheeler
222	16	Lasius (C.) brevicornis microps Wheeler
223	16	—
224	16	Lasius niger neoniger Emery
225	17	Aphaenogaster (A.) subterranea valida Wheeler
226	17	—
227	17	Lasius niger neoniger Emery
228	17	Aphaenogaster (A.) subterranea valida Wheeler
229	17	Lasius (C.) brevicornis microps Wheeler
230	17	Camponotus (T.) vicinus Mayr
231	17	—
232	17	Camponotus (T.) vicinus Mayr
233	17	Lasius (C.) umbratus aphidicola (Walsh)
234	17	—
235	17	Lasius niger neoniger Emery

TABLE VIII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
236	17	Formica fusca Linnaeus
237	17	—
238	17	Lasius (C.) brevicornis microps Wheeler
239	17	—
240	17	Aphaenogaster (A.) subterranea valida Wheeler
241	17	Lasius niger neoniger Emery
242	17	—
243	17	Formica fusca Linnaeus
244	17	Aphaenogaster (A.) subterranea valida Wheeler
245	17	Lasius niger neoniger Emery
246	17	—
247	17	Aphaenogaster (A.) subterranea valida Wheeler
248	17	—
249	17	Lasius niger neoniger Emery
250	18	Lasius (C.) umbratus aphidicola (Walsh)
251	18	Lasius (A.) claviger coloradensis Wheeler
252	18	Aphaenogaster (A.) subterranea valida Wheeler
253	18	—
254	18	—
255	18	—
256	18	—
257	18	Aphaenogaster (A.) subterranea valida Wheeler
258	18	—
		New Colonies for 1967
259	18	Aphaenogaster (A.) subterranea valida Wheeler
260	18	Formica (N.) pallidefulva Latreille
261	18	Formica (N.) pallidefulva nitidiventris Emery
262	18	Formica (N.) pallidefulva Latreille
263	18	Crematogaster lineolata (Say)
264	18	Leptothorax rugatulus Emery
265	18	Leptothorax rugatulus Emery
266	18	Lasius (C.) brevicornis microps Wheeler
267	18	Lasius (C.) brevicornis microps Wheeler
268	18	Aphaenogaster (A.) subterranea valida Wheeler
269	18	Lasius niger sitkaensis Pergande
270	18	Lasius (C.) brevicornis microps Wheeler
271	18	Aphaenogaster (A.) subterranea valida Wheeler

TABLE VIII (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 2

Colony number	Date	Species
	Aug.	
272	18	Formica (N.) pallidefulva Latreille
273	18	Lasius (C.) brevicornis microps Wheeler
274	19	Aphaenogaster (A.) subterranea valida Wheeler
275	19	Myrmica schencki emeryana Forel
276	19	Aphaenogaster (A.) subterranea valida Wheeler
277	19	Iridomyrmex pruinosus analis (E. Andre)
278	19	Lasius niger neoniger Emery
279	19	Aphaenogaster (A.) subterranea valida Wheeler
280	19	Lasius niger neoniger Emery
281	19	Lasius niger neoniger Emery
282	19	Aphaenogaster (A.) subterranea valida Wheeler
283	19	Aphaenogaster (A.) subterranea valida Wheeler
284	19	Tapinoma sessile (Say)
285	19	Lasius (C.) umbratus aphidicola (Walsh)
286	19	Aphaenogaster (A.) subterranea valida Wheeler
287	19	Lasius (C.) brevicornis microps Wheeler
288	19	Aphaenogaster (A.) subterranea valida Wheeler
289	19	Formica fusca Linnaeus
290	19	Formica fusca Linnaeus
291	19	Lasius niger neoniger Emery
292	19	Lasius niger neoniger Emery
293	19	Lasius (C.) brevicornis microps Wheeler
294	19	Lasius niger neoniger Emery
295	20	Lasius (C.) brevicornis microps Wheeler
296	20	Leptothorax rugatulus Emery
297	20	Tapinoma sessile (Say)
298	20	Formica (N.) pallidefulva Latreille
299	20	Aphaenogaster (A.) subterranea valida Wheeler
300	20	Aphaenogaster (A.) subterranea valida Wheeler
301	20	Leptothorax rugatulus Emery
302	20	Leptothorax rugatulus Emery
303	20	Formica fusca Linnaeus
304	20	Camponotus (T.) vicinus Mayr
305	20	Camponotus (T.) vicinus Mayr
306	20	Aphaenogaster (A.) subterranea valida Wheeler
307	20	Lasius (A.) latipes (Walsh)

TABLE IX

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 3

Colony number	Date	Species
	Aug.	
1	6	Formica obscuripes Forel
2	6	Solenopsis (D.) molesta validiuscula Emery
3	6	Lasius alienus americanus Emery
4	6	—
5	6	—
6	6	—
7	6	Solenopsis (D.) molesta validiuscula Emery
8	6	Lasius (C.) umbratus aphidicola (Walsh)
9	6	—
10	6	Lasius (C.) umbratus aphidicola (Walsh)
11	6	—
12	6	—
13	6	—
14	6	—
15	6	Lasius (A.) latipes (Walsh)
16	6	Formica obscuripes Forel
17	6	—
18	6	Lasius (C.) umbratus aphidicola (Walsh)
19	6	—
20	6	—
21	6	—
22	6	—
23	6	—
24	6	—
25	6	—
26	6	—
27	6	—
28	6	—
29	6	—
30	6	Lasius (C.) umbratus aphidicola (Walsh)
31	7	Formica (N.) pallidefulva nitidiventris Emery
32	7	—
33	7	Formica (N.) pallidefulva nitidiventris Emery
34	7	—
35	7	—
36	7	Lasius (C.) umbratus aphidicola (Walsh)
37	7	—
38	7	—
39	7	—

TABLE IX (Continued)

LIST OF ANT SPECIES FOUND IN 1967
IN QUADRAT 3

Colony number	Date	Species
	Aug.	
40	7	Lasius (C.) umbratus aphidicola (Walsh)
41	7	Lasius (C.) umbratus aphidicola (Walsh)
		New Colonies for 1967
42	7	Lasius (C.) umbratus aphidicola (Walsh)
43	7	Solenopsis (D.) molesta validiuscula Emery
44	7	Formica fusca Linnaeus
45	7	Tapinoma sessile (Say)
46	7	Formica (N.) pallidefulva nitidiventris Emery

TABLE X

RANGES AND ZONATION OF SPECIES

Species	Range	Altitudinal Range in feet	Zonation
Subfamily FORMICINAE			
Formica (*P.*) *limata* Emery	Rocky Mts. & N. & Midwest	5,000-9,700	Upper Sonoran, Transition, Canadian
Formica (*P.*) *lasioides* Wheeler	No. U.S. & S. into Mts.	4,800-10,505	Upper Sonoran, Transition, Canadian, Hudsonian
Formica (*N.*) *pallidefulva* Latreille	E. & S.E. U.S., Spotty in Midwest & Colo.	5,850-6,900	Transition
F. (*N.*) *pallidefulva nitidiventris* Emery	N. & E. U.S.	3,500-8,000	Upper Sonoran, Transition
Formica fusca Linnaeus	Holarctic, N. & S. into Mts.	5,154-12,500	Transition, Upper Sonoran, Canadian, Hudsonian
Formica fusca argentea Wheeler	E., Midwest, & W. U.S.	4,500-11,000	Upper Sonoran, Transition, Canadian, Hudsonian
Formica obscuripes Forel	N. U.S. and S. into Rockies	3,500-9,500	Upper Sonoran, Transition
F. Obscuriventris clivia Creighton	Mostly N. U.S. & S. into Rockies	5,354-10,000	Upper Sonoran, Transition, Canadian, Hudsonian
Camponotus (*T.*) *vicinus* Mayr	Midwest U.S. to W. Coast S. into Mex.	3,500-9,600	Upper Sonoran, Transition, Canadian
Lasius alienus americanus Emery	Holarctic, more in E. & Cent. U.S.	3,500-10,400	Upper Sonoran, Transition, Canadian, Hudsonian
Lasius niger neoniger Emery	E. and Midwest U.S.	3,500-12,400	Upper Sonoran, Transition, Canadian, Hudsonian, Arctic
Lasius niger sitkaensis Pergande	N. U.S. Transcontinental	4,600-12,200	Upper Sonoran, Transition, Canddian, Hudsonian, Arctic

TABLE X (Continued)

RANGES AND ZONATION OF SPECIES

Species	Range	Altitudinal Range in feet	Zonation
Lasius (C.) brevicornis microps Wheeler	N. U.S. Extensions S. & W.	5,700-9,700	Transition, Canadian
Lasius (C.) umbratus aphidicola (Walsh)	N.E. & E. U.S.	5,154-9,500	Upper Sonoran, Transition, Canadian
Lasius (A.) claviger coloradensis Wheeler	Rocky Mountain	5,100-8,000	Upper Sonoran, Transition
Lasius (A.) latipes (Walsh)	N. U.S. into E. Rockies & W. Mts.	4,800-8,500	Upper Sonoran, Transition
Subfamily DOLICHODERINAE			
Iridomyrmex pruinosus analis (E.Andre)	Western U.S.	3,500-6,300	Upper Sonoran, Transition
Liometopum occidentale luctuosum Wheeler	E. edge of Rocky Mts., Calif. Mts.	4,800-7,550	Upper Sonoran, Transition
Tapinoma sessile (Say)	Transcontinental U. S.	3,500-10,505	Upper Sonoran, Transition, Canadian, Hudsonian
Subfamily MYRMICINAE			
Crematogaster lineolata (Say)	N.E. & E. U.S.	5,400-6,500	Transition
Myrmica schencki emeryana Forel	E. and Midwest U.S.	5,800-9,713	U. Sonoran, Transition, Canadian
Aphaenogaster (A.) subterranea valida Wheeler	Rocky Mts., N.W. and W. U.S.	5,354-7,500	Upper Sonoran, Transition
Solenopsis (D.) molesta validiuscula Emery	WtoRocky Mts.	3,500-8,378	Upper Sonoran, Transition
Leptothorax rugatulus Emery	W. U.S., Rockies E. to Black Hills	5,354-8,700	Upper Sonoran, Transition
Pheidole pilifera coloradensis Emery	Rocky Mts. to Daks.	5,500-5,900	Upper Sonoran

TABLE XI

SPECIES COMPOSITION OF Q1

Species	1965 Colonies Number	1965 Colonies %	1965 Species Number	1966 Colonies Number	1966 Colonies %	1966 Species Number	1967 Colonies Number	1967 Colonies %	1967 Species Number
Lasius (*C.*) *umbratus aphidicola* (Walsh)	6	7.3		1	1.9		2	3.5	
L. alienus americanus Emery	5	6.1		3	5.8		2	3.5	
L. niger neoniger Emery	2	2.4		1	1.9				
L. claviger coloradensis Wheeler	1	1.2							
L. (*A.*) *latipes* (Walsh)							1	1.7	
Formica (*N.*) *pallidefulva* Latreille	32	39.0		22	42.3		21	36.8	
F. (*P.*) *lasioides* Emery	2	2.4		1	1.9		1	1.7	
F. obscuriventris clivia Creighton	1	1.2		1	1.9		1	1.7	
Camponotus (*T.*) *vicinus* Mayr	8	9.8		9	17.3		9	15.8	
FORMICINAE	57	69.4	8	38	73.0	7	37	64.7	7
Crematogaster lineolata (Say)							1	1.7	
Aphaenogaster (*A.*) *subterranea valida* Wheeler	8	9.8		6	11.5		6	10.5	
Solenopsis (*D.*) *molesta validiuscula* Emery	7	8.5		1	1.9		10	17.5	
Myrmica schencki emeryana Forel	1	1.2		3	5.8				
Pheidole pilifera coloradensis Emery	1	1.2		1	1.9		1	1.7	
MYRMICINAE	17	20.7	4	11	21.1	4	18	31.4	4
Iridomyrmex pruinosus analis (E. Andre)	2	2.4		2	3.8		1	1.7	
Tapinoma sessile (Say)	6	7.3		1	1.9		1	1.7	
DOLICHODERINAE	8	9.7	2	3	5.7	2	2	3.4	2
TOTALS	82	99.8	14	52	99.8	13	57	99.5	13

TABLE XII

SPECIES COMPOSITION OF Q2

Species	1965 Colonies Number	1965 Colonies %	1965 Species Number	1966 Colonies Number	1966 Colonies %	1966 Species Number	1967 Colonies Number	1967 Colonies %	1967 Species Number
Lasius (C.) umbratus aphidicola (Walsh)	3	1.5		3	2		6	3.6	
L. niger neoniger Emery	44	21.5		30	20.1		29	17.6	
L. (A.) claviger coloradensis Wheeler							1	.6	
L. (A.) latipes (Walsh)	4	2.0		1	.7		2	1.2	
L. (C.) brevicornis microps Wheeler	25	12.2		21	14.1		22	13.3	
L. niger sitkaensis Pergande	4	2.0		4	2.7		2	1.2	
Formica (N.) pallidefulva Latreille	6	2.9		4	2.7		6	3.6	
F. (N.) pallidefulva nitidiventris Emery	2	1.0					1	.6	
F. (P.) limata Wheeler							1	.6	
F. fusca Linnaeus	9	4.4		7	4.7		8	4.8	
F. (P.) lasioides Emery	1	.5		1	.7		1	.6	
Camponotus (T.) vicinus Mayr	15	7.3		16	10.7		9	5.5	
FORMICINAE	113	55.3	10	87	58.4	9	88	53.2	12
Crematogaster lineolata (Say)	6	2.9		1	.7		5	3.0	
Aphaenogaster (A.) subterranea valida Wheeler	52	25.4		48	32.2		44	26.7	
Myrmica schencki emeryana Forel							1	.6	
Solenopsis (D.) molesta validiuscula Emery	2	1.0					5	3.0	
Leptothorax rugatulus Emery	6	2.9		5	3.4		12	7.3	
MYRMICINAE	66	32.2	4	54	36.3	3	67	40.6	5
Iridomyrmex pruinosus analis (E. Andre)							1	.6	
Liometopum occidentale luctuosum Wheeler	7	3.4		3	2.0		1	.6	
Tapinoma sessile (Say)	19	9.3		5	3.4		8	4.8	
DOLICHODERINAE	26	12.7	2	8	5.4	2	10	6.0	3
TOTALS	205	100.2	16	149	100.1	14	165	99.8	20

TABLE XIII

SPECIES COMPOSITION OF Q3

Species	1965 Colonies Number	1965 Colonies %	1965 Species Number	1966 Colonies Number	1966 Colonies %	1966 Species Number	1967 Colonies Number	1967 Colonies %	1967 Species Number
Lasius (C.) umbratus aphidicola (Walsh)	12	35.3		6	24		8	40	
L. (A.) latipes (Walsh)	3	8.8		2	8		1	5	
L. alienus americanus Emery	6	17.6		2	8		1	5	
Formica obscuripes Forel	1	2.9		2	8		2	10	
F. fusca Linnaeus							1	5	
F. fusca argentea Wheeler	1	2.9							
F. (N.) pallidefulva nitidiventris Emery	1	2.9		2	8		3	15	
FORMICINAE	24	70.4	6	14	56	5	16	80	6
Aphaenogaster (A.) subterranea valida Wheeler	8	23.5		1	4		3	15	
Solenopsis (D.) molesta validiuscula Emery				8	32				
MYRMICINAE	8	23.5	1	9	36	2	3	15	1
Tapinoma sessile (Say)	2	5.9		2	8		1	5	
DOLICHODERINAE	2	5.9	1	2	8	1	1	5	1
TOTALS	34	99.8	8	25	100	8	20	100	8

TABLE XIV

ANT SUBFAMILY COMPOSITION

Area	FORMICINAE Colonies						MYRMICINAE Colonies						DOLICHODERINAE Colonies					
	1965		1966		1967		1965		1966		1967		1965		1966		1967	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Q1	57	69.4	38	73	37	64.7	17	20.7	11	21.1	18	31.4	8	9.7	3	5.7	2	3.4
Q2	113	55.3	87	58.4	88	53.2	66	32.2	54	36.3	67	40.6	26	12.7	8	5.4	10	6
Q3	24	70.4	14	56	16	80	8	23.5	9	36	3	15	2	5.9	2	8	1	5
Colony Totals	194		139		141		91		74		88		36		13		13	

TABLE XV

ESTIMATION OF ANT COLONY SIZE BY THE LINCOLN INDEX

Colony	Marked First Day	Recaptured second day Marked	Recaptured second day Unmarked	Colony density by Index	Colony density by Actual Count
Camponotus (T.) vicinus	50	4	56	750	60
Camponotus (T.) vicinus	25	1	1	50	79
Camponotus (T.) vicinus	30	9	19	93	142
Camponotus (T.) vicinus	50	5	8	130	273
Formica (N.) pallidefulva Latreille	25	8	16	75	117
Formica (N.) pallidefulva Latreille	40	6	11	113	149

TABLE XVI

MORNING TEMPERATURE READINGS

Date	Time A.M.	Area	Subsurface 2-3" below	Surface	6" above ground	5' above ground	Sky condition
7/29	8:00	Q1	65.5	67.8	78.8	77.8	Clear
		Q2	63.9	64.5	73.1	75.0	
		Q3	67.0	67.9	77.9	78.3	
7/30	8:00	Q1	63.2	68.5	80.5	81.4	Clear
		Q2	65.5	76.4	80.9	81.5	
		Q3	67.9	70.6	78.3	79.7	
7/31	7:00	Q1	63.5	49.3	46.5	46.5	Overcast
		Q2	61.5	55.7	48.6	48.2	
		Q3	65.5	52.8	49.5	48.5	
8/1	6:30	Q1	59.8	57.5	54.5	55.5	Ptly Cldy
		Q2	59.5	55.0	52.9	53.4	
		Q3	62.4	54.5	51.6	51.5	
8/2	6:30	Q1	61.6	63.6	66.3	67.8	Ptly Cldy
		Q2	64.2	62.9	69.3	68.5	
		Q3	66.5	63.6	62.3	63.9	
8/3	6:30	Q1	61.8	60.9	61.0	61.9	Ptly Cldy
		Q2	63.4	60.7	60.1	60.9	
		Q3	66.1	63.5	62.4	62.1	
8/4	6:30	Q1	61.3	58.1	61.3	62.6	Fair
		Q2	61.9	57.6	61.6	63.5	
		Q3	65.2	61.6	61.1	64.6	
8/5	6:15	Q1	68.5	66.4	64.3	70.0	Fair
		Q2	64.9	63.8	65.1	69.0	
		Q3	66.9	61.3	60.5	66.0	
8/6	6:30	Q1	63.8	63.0	66.1	68.0	Fair
		Q2	66.0	64.5	66.2	68.5	
		Q3	67.1	61.5	62.0	65.9	
8/7	6:45	Q1	64.6	64.2	69.3	71.0	Fair
		Q2	66.3	70.0	71.8	72.2	
		Q3	68.0	69.8	70.0	72.5	
8/8	6:30	Q1	63.9	64.1	65.4	66.1	Ptly Cldy
		Q2	66.3	64.0	65.2	65.9	
		Q3	66.9	64.8	66.1	67.2	

TABLE XVI (Continued)

MORNING TEMPERATURE READINGS

Date	Time A.M.	Area	Subsurface 2-3" below	Surface	6" above ground	5' above ground	Sky condition
8/9	7:00	Q1	63.9	63.0	63.8	64.2	Cloudy
		Q2	66.0	64.9	63.8	64.4	
		Q3	67.9	67.2	66.5	65.4	
8/10	7:30	Q1	60.1	57.4	55.1	54.2	Rain
		Q2	61.1	59.0	55.9	55.0	
		Q3	62.9	60.8	56.7	55.1	
8/11	8:00	Q1	59.1	55.7	53.5	53.0	Cloudy
		Q2	59.3	56.1	54.3	53.3	
		Q3	61.4	59.1	55.9	54.2	
8/12	7:30	Q1	60.1	61.5	62.3	63.4	Fair
		Q2	60.8	57.7	61.5	63.1	
		Q3	62.2	62.2	65.6	66.9	
8/13	7:30	Q1	61.1	62.5	64.8	66.5	Fair
		Q2	61.6	58.1	62.0	64.1	
		Q3	62.0	61.9	66.2	67.1	
8/14	7:30	Q1	60.4	59.1	59.3	59.7	Cloudy
		Q2	62.4	60.0	59.3	60.1	
		Q3	63.9	62.3	59.0	56.4	
8/15	7:30	Q1	58.7	57.2	63.8	64.4	Fair
		Q2	59.0	53.8	60.2	62.4	
		Q3	59.1	59.5	66.4	67.8	
8/16	7:30	Q1	59.5	67.1	67.7	67.8	Fair
		Q2	61.7	60.2	62.4	64.6	
		Q3	62.0	59.8	68.9	69.0	
8/17	7:30	Q1	59.5	57.3	57.8	57.0	Ptly Cldy
		Q2	61.2	58.1	56.8	56.1	
		Q3	62.7	60.6	59.5	60.0	
8/18	7:30	Q1	58.2	63.1	64.8	64.9	Fair
		Q2	60.3	59.9	60.3	61.6	
		Q3	62.7	62.1	64.9	66.2	

TABLE XVI (Continued)

MORNING TEMPERATURE READINGS

Date	Time A.M.	Area	Subsurface 2-3" below	Surface	6" above ground	5' above ground	Sky condition
8/19	7:30	Q1	59.1	58.8	59.8	59.7	Fair
		Q2	61.0	57.5	58.0	58.7	
		Q3	62.6	60.9	59.9	60.1	
8/20	7:15	Q1	60.1	64.3	66.2	67.5	Ptly Cldy
		Q2	63.1	64.4	67.0	69.8	
		Q3	63.3	65.0	67.5	71.1	
8/21	7:00	Q1	61.8	67.4	69.9	70.0	Fair
		Q2	65.0	66.3	69.7	69.9	
		Q3	65.9	68.0	69.9	70.6	
8/22	7:15	Q1	60.9	60.9	61.7	64.0	Ptly Cldy
		Q2	64.1	61.8	62.6	64.1	
		Q3	64.8	63.0	65.2	66.5	
8/23	7:15	Q1	59.8	58.4	57.4	57.3	Fair
		Q2	62.1	55.9	55.6	56.0	
		Q3	62.7	60.3	58.9	58.8	
8/24	7:45	Q1	57.7	57.1	65.1	63.0	Fair
		Q2	61.2	59.5	58.7	59.4	
		Q3	59.8	59.9	60.3	59.2	
8/25	7:15	Q1	58.9	61.3	64.4	64.9	Fair
		Q2	62.1	59.8	60.7	61.6	
		Q3	62.2	62.7	64.4	66.2	
8/26	7:30	Q1	60.2	65.7	66.7	66.9	Ptly Cldy
		Q2	63.3	62.7	66.4	68.3	
		Q3	63.6	66.8	69.2	69.7	
8/27	7:30	Q1	61.2	70.0	70.6	71.0	Cloudy
		Q2	64.9	70.1	71.5	72.1	
		Q3	66.6	69.7	71.0	71.2	
8/28	7:30	Q1	60.6	63.2	64.1	63.2	Fair
		Q2	63.1	61.8	60.7	61.1	
		Q3	63.8	63.7	63.2	63.5	

TABLE XVII

NOON TEMPERATURE READINGS

Date	Time P.M.	Area	Subsurface 2-3" below	Surface	6" above ground	5' above ground	Sky condition
7/29	12:00	Q1	66.1	85.5	86.2	85.6	Ptly Cldy
		Q2	67.9	86.2	91.5	90.5	
		Q3	74.7	84.5	86.3	86.4	
7/30	12:00	Q1	66.1	80.5	81.1	81.5	Cloudy
		Q2	67.2	82.4	85.4	84.2	
		Q3	74.5	90.9	88.4	83.2	
7/31	12:00	Q1	59.9	59.9	60.4	57.9	Ptly Cldy
		Q2	62.3	59.0	59.8	60.9	
		Q3	66.9	68.9	65.8	62.5	
8/1	12:00	Q1	64.5	69.9	74.4	74.8	Fair
		Q2	63.2	77.2	78.8	77.9	
		Q3	70.5	80.5	80.4	75.6	
8/2	12:00	Q1	64.3	70.1	75.8	75.1	Ptly Cldy
		Q2	65.9	78.4	77.2	77.9	
		Q3	67.9	79.9	82.4	80.1	
8/3	12:00	Q1	64.0	72.3	72.7	72.6	Cloudy
		Q2	67.9	72.9	72.1	72.2	
		Q3	70.3	81.3	78.2	75.5	
8/4	12:30	Q1	65.2	76.2	81.3	82.5	Fair
		Q2	68.9	81.7	84.0	84.2	
		Q3	75.4	86.4	88.3	84.2	
8/5	12:00	Q1	64.7	75.9	77.3	81.5	Cloudy
		Q2	68.6	80.2	81.4	86.0	
		Q3	72.1	83.8	85.9	87.8	
8/6	12:00	Q1	65.1	76.1	79.6	81.1	Ptly Cldy
		Q2	68.9	85.3	85.1	85.9	
		Q3	73.3	90.0	85.8	84.9	
8/7	12:00	Q1	65.8	76.6	80.9	83.1	Ptly Cldy
		Q2	69.4	84.2	86.3	87.8	
		Q3	75.1	95.3	94.9	89.6	
8/8	12:00	Q1	65.5	82.4	84.7	83.5	Fair
		Q2	69.9	87.0	85.6	85.2	
		Q3	78.0	97.2	96.9	88.8	

TABLE XVII (Cont'd.)

NOON TEMPERATURE READINGS

Date	Time	Area	Subsurface 2-3" below	Surface	6" above ground	5' above ground	Sky condition
8/9	12:30	Q1	63.2	64.5	63.2	62.5	Drizzle
		Q2	65.9	62.9	62.0	61.6	
		Q3	68.0	68.2	64.9	62.1	
8/10	12:30	Q1	60.8	57.0	54.9	54.1	Rain
		Q2	61.5	59.9	56.5	54.3	
		Q3	63.6	60.2	56.1	55.5	
8/11	11:30	Q1	59.1	57.4	56.7	55.5	Overcast
		Q2	60.0	58.8	58.6	57.3	
		Q3	63.5	62.0	61.1	60.9	
8/12	12:00	Q1	61.8	72.1	75.3	76.7	Ptly Cldy
		Q2	65.4	76.0	75.2	75.4	
		Q3	67.9	77.5	81.8	81.0	
8/13	12:00	Q1	63.3	72.4	74.9	74.0	Fair
		Q2	64.2	77.1	78.2	78.5	
		Q3	68.4	73.0	73.7	74.3	
8/14	12:00	Q1	61.7	62.1	63.0	62.3	Overcast
		Q2	63.8	64.1	64.2	63.2	
		Q3	66.6	65.1	66.1	65.9	
8/15	11:30	Q1	59.8	66.4	69.1	70.0	Fair
		Q2	62.6	68.3	70.1	69.9	
		Q3	65.9	73.2	74.3	72.8	
8/16	11:30	Q1	60.8	69.3	71.1	70.2	Fair
		Q2	64.3	68.2	70.4	72.2	
		Q3	66.4	77.2	73.1	72.3	
8/17	11:30	Q1	60.1	66.5	67.7	65.1	Mstly Fair
		Q2	63.6	70.0	69.1	67.9	
		Q3	69.1	70.1	74.2	68.0	
8/18	12:00	Q1	62.2	74.3	75.3	76.7	Mstly Fair
		Q2	63.5	73.1	73.4	73.7	
		Q3	69.6	78.5	78.3	78.1	

TABLE XVII (Continued)

NOON TEMPERATURE READINGS

Date	Time	Area	*Subsurface* 2-3" below	Surface	*6" above* ground	*5' above* ground	*Sky* condition
8/19	12:30	Q1	61.3	72.1	71.2	73.1	Mstly Fair
		Q2	69.0	72.5	72.7	72.4	
		Q3	71.4	79.9	81.8	80.9	
8/20	11:30	Q1	62.1	77.3	78.3	77.0	Ptly cloudy
		Q2	64.9	80.3	81.1	81.2	
		Q3	66.6	77.8	82.8	82.3	
8/21	12:00	Q1	65.6	75.0	76.9	78.9	Mstly Fair
		Q2	66.8	76.3	78.8	80.3	
		Q3	72.5	86.2	84.0	80.6	
8/22	12:30	Q1	63.4	75.5	77.4	77.6	Ptly Cldy
		Q2	68.3	76.4	77.1	78.0	
		Q3	70.8	85.1	84.7	83.0	
8/23	12:30	Q1	61.0	66.6	67.3	68.1	Fair
		Q2	67.4	6611	68.0	66.3	
		Q3	69.8	75.1	70.9	71.3	
8/24	12:15	Q1	59.8	69.2	69.5	67.0	Fair
		Q2	60.7	68.1	68.0	68.8	
		Q3	69.3	76.3	75.7	68.9	
8/25	1:00	Q1	61.3	70.0	77.2	79.3	Ptly Cldy
		Q2	68.2	87.2	86.2	80.3	
		Q3	72.6	86.8	87.2	84.3	
8/26	12:00	Q1	62.1	80.6	80.4	79.9	Ptly Cldy
		Q2	66.3	82.8	84.3	82.2	
		Q3	69.7	89.9	85.6	81.3	
8/27	11:45	Q1	62.3	82.2	81.0	79.1	Ptly Cldy
		Q2	66.3	84.2	82.2	81.8	
		Q3	69.4	78.8	78.3	81.4	
8/28	12:00	Q1	62.4	72.6	76.5	76.7	Ptly Cldy
		Q2	68.5	77.4	78.8	79.3	
		Q3	70.0	81.4	81.8	77.7	

TABLE XVIII

AFTERNOON TEMPERATURE READINGS

Date	Time	Area	Subsurface 2-3" below	Surface	6" above ground	5' above ground	Sky condition
7/29	4:30	Q1	63.7	74.3	75.1	74.4	Ptly cldy
		Q2	66.5	77.2	75.5	74.5	
		Q3	76.2	78.3	77.5	75.9	
7/30	4:30	Q1	70.4	68.5	69.5	70.1	Hd rained
		Q2	67.8	68.5	66.2	67.5	
		Q3	72.4	67.9	67.5	70.8	
7/31	4:30	Q1	60.0	59.1	57.0	57.5	Rain
		Q2	64.5	60.1	55.5	53.5	
		Q3	68.5	67.0	64.5	63.4	
8/1	5:30	Q1	66.4	69.3	71.5	72.1	Ptly cldy
		Q2	68.8	70.3	71.2	72.3	
		Q3	73.5	73.2	73.1	74.4	
8/2	5:20	Q1	66.5	69.9	76.2	77.4	Fair
		Q2	67.7	77.3	79.1	79.8	
		Q3	73.9	81.9	82.7	82.1	
8/3	5:30	Q1	66.0	65.5	62.8	65.3	Ptly cldy
		Q2	65.3	63.9	67.2	68.2	
		Q3	70.5	68.0	69.2	69.9	
8/4	5:00	Q1	67.5	83.1	82.8	82.9	Ptly cldy
		Q2	73.4	84.1	83.8	83.8	
		Q3	75.1	81.1	83.2	85.0	
8/5	4:45	Q1	66.8	76.1	78.3	78.8	Cloudy
		Q2	68.3	77.9	78.0	77.8	
		Q3	72.9	79.0	79.7	81.6	
8/6	5:00	Q1	66.8	80.5	81.8	83.1	Ptly cldy
		Q2	72.5	83.0	81.9	81.9	
		Q3	78.9	82.4	83.0	82.7	
8/7	4:45	Q1	70.2	79.0	77.9	77.6	Ptly cldy
		Q2	70.0	78.6	78.3	77.2	
		Q3	75.3	82.2	82.5	82.6	
8/8	5:00	Q1	67.2	70.3	76.1	77.9	Hd rained
		Q2	69.4	71.1	77.0	78.3	
		Q3	74.0	78.1	82.1	83.2	

TABLE XVIII (Continued)

AFTERNOON TEMPERATURE READINGS

Date	Time	Area	Subsurface 2-3" below	Surface	6" above ground	5' above ground	Sky condition
8/9	5:00	Q1	63.4	64.1	63.0	61.2	Rain
		Q2	65.7	63.2	63.1	60.3	
		Q3	68.4	68.9	65.1	61.6	
8/10	5:00	Q1	60.0	57.1	54.4	51.2	Rain
		Q2	60.8	59.3	55.6	52.4	
		Q3	61.3	59.6	56.0	53.1	
8/11	5:00	Q1	61.1	66.7	67.2	68.9	Ptly cldy
		Q2	65.4	66.5	67.8	69.1	
		Q3	66.9	66.1	68.4	69.9	
8/12	4:45	Q1	63.7	66.9	68.5	71.3	Cloudy
		Q2	68.0	70.1	70.8	71.9	
		Q3	72.5	71.2	72.9	74.0	
8/13	4:30	Q1	64.2	66.1	70.5	72.8	Slt rain
		Q2	67.3	70.1	71.7	73.0	
		Q3	70.9	70.3	72.1	74.1	
8/14	4:45	Q1	62.2	60.1	56.9	57.3	Rain
		Q2	66.2	60.3	56.6	56.1	
		Q3	68.0	61.9	62.3	64.3	
8/15	6:30	Q1	62.4	63.9	67.3	68.0	Fair
		Q2	61.3	66.6	68.5	69.1	
		Q3	69.3	67.0	68.7	69.9	
8/16	5:30	Q1	63.0	70.9	72.7	73.9	Fair
		Q2	68.5	71.3	72.1	71.8	
		Q3	72.2	72.5	75.1	76.3	
8/17	5:00	Q1	62.7	72.2	73.2	74.0	Ptly cldy
		Q2	69.9	76.9	76.4	73.9	
		Q3	72.8	81.0	79.9	78.8	
8/18	5:30	Q1	61.9	71.4	72.0	72.3	Fair
		Q2	68.9	72.2	72.4	73.7	
		Q3	71.9	73.2	76.5	76.9	

TABLE XVIII (Continued)

AFTERNOON TEMPERATURE READINGS

Date	Time	Area	Subsurface 2-3" below	Surface	6" above ground	5' above ground	Sky condition
8/19	5:00	Q1	62.1	72.2	73.8	75.2	Ptly cldy
		Q2	68.9	73.3	74.1	74.2	
		Q3	73.9	76.1	78.0	77.7	
8/20	5:00	Q1	64.2	76.2	77.3	78.3	Fair
		Q2	70.9	81.4	80.2	79.8	
		Q3	74.1	79.1	81.0	84.9	
8/21	5:30	Q1	64.2	72.4	73.8	74.3	Ptly cldy
		Q2	70.1	72.3	72.9	73.0	
		Q3	74.7	74.9	73.3	73.9	
8/22	5:00	Q1	64.1	73.2	73.9	73.5	Ptly cldy
		Q2	73.2	77.3	76.2	75.9	
		Q3	74.4	75.7	75.8	76.0	
8/23	5:45	Q1	61.6	65.0	65.8	66.1	Fair
		Q2	68.3	67.0	66.8	66.8	
		Q3	70.2	70.4	70.0	69.2	
8/24	5:15	Q1	60.9	63.1	68.2	69.7	Fair
		Q2	68.5	69.6	70.0	69.9	
		Q3	72.3	74.8	76.1	75.1	
8/25	5:30	Q1	62.7	67.4	74.3	74.8	Ptly cldy
		Q2	69.4	72.1	74.4	75.0	
		Q3	72.9	73.0	73.5	74.7	
8/26	5:00	Q1	63.7	76.4	77.9	78.3	Ptly cldy
		Q2	69.8	80.4	80.0	80.1	
		Q3	72.8	81.2	79.8	80.4	
8/27	4:30	Q1	64.1	72.5	72.8	71.4	Cloudy
		Q2	70.7	72.5	70.9	70.4	
		Q3	72.0	73.3	73.1	72.3	
8/28	5:00	Q1	63.1	66.5	70.3	72.2	Ptly cldy
		Q2	68.6	72.2	71.4	72.6	
		Q3	71.1	75.6	76.4	77.3	

TABLE XIX

WEEKLY MORNING TEMPERATURE AVERAGES IN ALL QUADRATS

Date	Area	Subsurface	Surface	6" above ground	5' above ground
7/29-8/4	Q1	62.4	60.8	64.1	64.8
	Q2	62.8	61.8	63.8	64.4
	Q3	65.8	62.1	63.3	64.1
8/5-8/11	Q1	63.4	62.0	62.5	63.8
	Q2	64.3	63.2	63.2	64.0
	Q3	65.9	63.5	62.5	63.8
8/12-8/18	Q1	59.6	61.1	62.9	63.4
	Q2	61.0	58.3	60.4	61.7
	Q3	62.1	61.2	64.4	64.8
8/19-8/25	Q1	59.8	61.2	63.5	63.8
	Q2	62.7	60.7	61.8	62.8
	Q3	63.0	62.8	63.7	64.6
8/26-8/28*	Q1	60.7	66.3	67.1	67.0
	Q2	63.8	64.9	66.2	67.2
	Q3	64.7	66.7	67.8	68.1

*For only a three day period.

TABLE XXI

WEEKLY NOON TEMPERATURE AVERAGES IN ALL QUADRATS

Date	Area	Subsurface	Surface	6" above ground	5' above ground
7/29-8/4	Q1	64.3	73.5	76.0	75.7
	Q2	66.2	76.8	78.4	78.3
	Q3	71.5	81.8	81.4	78.2
8/5-8/11	Q1	63.5	70.0	71.0	71.6
	Q2	66.3	74.0	73.6	74.0
	Q3	70.5	79.5	77.9	75.7
8/12-8/18	Q1	61.4	69.0	70.9	70.7
	Q2	63.9	71.0	71.5	71.5
	Q3	67.7	73.5	74.5	73.2
8/19-8/25	Q1	62.1	72.2	74.0	74.4
	Q2	65.0	75.3	76.0	75.3
	Q3	70.4	81.0	81.0	78.8
8/26-8/28*	Q1	62.3	78.5	79.3	78.6
	Q2	67.0	81.5	81.8	81.1
	Q3	69.7	83.4	81.9	80.1

*For only a three day period.

TABLE XXII

WEEKLY AFTERNOON TEMPERATURE AVERAGES IN ALL QUADRATS

Date	Area	Subsurface	Surface	6" above ground	5' above ground
7/29-8/4	Q1	65.8	70.0	70.7	71.4
	Q2	67.7	71.6	71.2	71.4
	Q3	72.9	73.9	74.0	74.5
8/5-8/11	Q1	65.1	70.5	71.2	71.2
	Q2	67.4	71.4	71.7	71.0
	Q3	71.1	73.8	73.8	73.5
8/12-8/18	Q1	62.9	67.4	68.7	69.9
	Q2	67.2	69.6	69.8	69.9
	Q3	71.1	71.0	72.5	73.5
8/19-8/25	Q1	62.8	69.9	72.4	73.1
	Q2	69.9	73.3	73.5	73.5
	Q3	73.2	74.9	75.4	75.9
8/26-8/28*	Q1	63.6	71.8	73.7	74.0
	Q2	69.7	75.0	74.1	31.9
	Q3	72.0	76.7	76.4	76.7

*For only a three day period.

TABLE XXIII

WEEKLY MORNING TEMPERATURE EXTREMES IN ALL QUADRATS

		Subsurface		Surface		6" above surf		5' above surf	
Date	Area	Max	Min	Max	Min	Max	Min	Max	Min
7/29-8/4	Q1	65.5	59.8	68.5	49.3	80.5	46.5	81.4	46.5
	Q2	65.5	59.5	76.4	55.0	80.9	48.6	81.5	48.2
	Q3	67.9	65.2	70.6	52.8	78.3	49.5	79.7	48.5
8/5-8/11	Q1	68.5	59.1	66.4	55.7	69.3	53.5	71.0	53.0
	Q2	66.3	59.3	70.0	56.1	71.8	54.3	72.2	53.3
	Q3	68.0	61.4	69.8	59.1	70.0	55.9	72.5	54.2
8/12-8/18	Q1	61.1	58.2	67.1	57.2	67.7	57.8	67.8	57.0
	Q2	62.4	59.0	60.2	53.8	62.4	56.8	64.6	56.1
	Q3	63.9	59.1	62.3	59.5	68.9	59.0	69.0	56.4
8/19-8/25	Q1	61.8	57.7	67.4	57.1	69.9	57.4	70.0	57.3
	Q2	65.0	61.0	66.3	55.9	69.7	55.6	69.9	56.0
	Q3	65.9	59.8	68.0	59.9	69.9	58.9	70.6	58.8
8/26-8/28*	Q1	61.2	60.2	70.0	63.2	70.6	64.1	71.0	63.2
	Q2	64.9	63.1	70.1	61.8	71.5	60.7	72.1	61.1
	Q3	66.6	63.6	69.7	63.7	71.0	63.2	71.2	63.5

*For only a three day period.

TABLE XXIII

WEEKLY NOON TEMPERATURE EXTREMES IN ALL QUADRATS

Date	Area	Subsurface Max	Subsurface Min	Surface Max	Surface Min	6" above surf Max	6" above surf Min	5' above surf Max	5' above surf Min
7/29-8/4	Q1	66.1	59.9	85.5	59.9	86.2	60.4	85.6	57.9
	Q2	68.9	62.3	86.2	59.0	91.5	59.8	90.5	60.9
	Q3	75.4	66.9	90.9	68.9	88.4	65.8	86.4	62.5
8/5-8/11	Q1	65.8	59.1	82.4	57.0	84.7	54.9	83.5	54.1
	Q2	69.9	60.0	87.0	58.8	86.3	56.5	87.8	54.3
	Q3	78.0	63.5	97.2	60.2	96.9	56.1	89.6	55.5
8/12-8/18	Q1	63.3	59.8	74.3	62.1	75.3	63.0	76.7	62.3
	Q2	65.4	62.6	77.1	64.1	78.2	69.1	78.5	63.2
	Q3	69.6	65.9	78.5	65.1	81.8	66.1	81.0	65.9
8/19-8/25	Q1	65.6	59.8	77.3	66.6	78.3	67.3	79.3	67.0
	Q2	69.0	60.7	87.2	66.1	86.2	68.0	81.2	66.3
	Q3	72.6	66.6	86.8	75.1	87.2	70.9	84.3	68.9
8/26-8/28*	Q1	62.4	62.1	82.2	72.6	81.0	76.5	79.9	76.7
	Q2	68.5	66.3	84.2	77.4	84.3	78.8	82.2	79.3
	Q3	70.0	69.4	81.4	78.8	81.8	78.3	81.4	77.7

*For only a three day period.

TABLE XXIV

WEEKLY AFTERNOON TEMPERATURE EXTREMES IN ALL QUADRATS

Date	Area	Subsurface Max	Subsurface Min	Surface Max	Surface Min	6" above surf Max	6" above surf Min	5' above surf Max	5' above surf Min
7/29-8/4	Q1	70.4	60.0	83.1	59.1	82.8	57.0	82.9	57.5
	Q2	73.4	64.5	84.1	60.1	83.8	55.5	83.8	53.5
	Q3	76.2	68.5	81.9	67.0	83.2	64.5	85.0	63.4
8/5-8/11	Q1	70.2	60.0	80.5	57.1	81.8	54.4	83.1	51.2
	Q2	72.5	60.8	83.0	59.3	81.9	55.6	81.9	52.4
	Q3	78.9	61.3	82.4	59.6	83.0	56.0	83.2	53.1
8/12-8/18	Q1	64.2	61.9	72.2	60.1	73.2	56.9	74.0	57.3
	Q2	69.9	61.3	76.9	60.3	76.4	56.6	73.9	56.1
	Q3	72.8	68.0	81.0	61.9	79.9	62.3	78.8	64.3
8/19-8/25	Q1	64.2	60.9	76.2	63.1	77.3	65.8	78.3	66.1
	Q2	73.2	68.3	81.4	67.0	80.2	66.8	79.8	66.8
	Q3	74.4	70.2	79.1	70.4	81.0	70.0	84.9	69.2
8/26-8/28*	Q1	64.1	63.1	76.4	66.5	77.9	70.3	78.3	71.4
	Q2	70.7	68.6	80.4	72.2	80.0	70.9	80.1	70.4
	Q3	72.8	71.1	81.2	73.3	79.8	73.1	80.4	72.3

*For only a three day period.

TABLE XXV

U.S. WEATHER BUREAU
RECORD OF CLIMATOLOGICAL OBSERVATIONS
STATION—BOULDER, COLORADO
TIME OF OBSERVATION 5:30 P.M.

Date 1965 June	Temp. Boulder 24 Hrs. ending at observation Max.	Min.	at Obsn.	Precipitation S. Boulder Ins & Hundredths
1	75	57	62	.15
2	77	48	68	
3	77	50	70	
4	75	51	51	.30
5	62	44	57	1.20
6	80	43	73	
7	80	60	74	.03
8	74	49	61	.06
9	74	54	69	T
10	69	56	56	.04
11	67	51	61	.36
12	71	51	61	T
13	82	56	72	.01
14	79	58	58	
15	77	56	76	T
16	77	56	61	.10
17	76	55	70	.25
18	78	55	75	T
19	85	57	81	
20	83	55	76	
21	81	53	80	
22	89	65	72	T
23	82	59	82	
24	82	55	79	.06
25	82	59	75	
26	85	55	80	
27	80	58	78	
28	84	55	77	
29	83	59	65	
30	81	62	75	.10
July				Sum 2.66
1	89	58	85	
2	85	57	78	
3	88	54	87	
4	90	60	88	
5	89	61	85	
6	90	58	83	

TABLE XXV (Continued)

U.S. WEATHER BUREAU
RECORD OF CLIMATOLOGICAL OBSERVATIONS
STATION--BOULDER, COLORADO
TIME OF OBSERVATION 5:30 P.M.

Date 1965 July	Temp. Boulder 24 Hrs. Ending at Observation Max.	Min.	at Obsn.	Precipitation S. Boulder Ins & Hundredths
7	90	61	88	
8	89	65	81	T
9	86	58	81	.25
10	94	57	80	T
11	89	63	88	.01
12	87	65	84	.02
13	84	55	81	T
14	89	54	87	
15	92	61	87	
16	94	65	89	
17	90	62	84	
18	90	67	87	
19	88	65	81	.32
20	86	60	81	T
21	87	54	84	.75
22	92	62	86	.49
23	83	63	73	T
24	74	60	69	1.07
25	77	57	72	.98
26	83	57	80	.10
27	76	61	64	T
28	80	55	71	
29	87	60	85	
30	86	61	81	.28
31	67	56	57	.84
			Sum	5.11

TABLE XXVI

U.S. WEATHER BUREAU
RECORD OF CLIMATOLOGICAL OBSERVATIONS
STATION--BOULDER, COLORADO
TIME OF OBSERVATION 5:30 P.M.

Date 1966 August	Temp. Boulder 24 Hrs. Ending at Observation Max.	Min.	at Obsn.	Precipitation S. Boulder Ins. & Hundredths
1	81	66	67	.16
2	84	67	67	.25
3	84	60	75	.02
4	81	59	77	.04
5	87	54	82	
6	92	61	82	
7	84	57	79	
8	79	56	65	
9	77	58	74	T
10	82	54	78	T
11	95	56	86	
12	89	60	69	T
13	85	50	85	
14	90	61	83	
15	87	55	82	
16	96	63	94	
17	94	73	74	
18	87	56	82	
19	85	66	67	.04
20	77	57	72	
21	74	52	70	
22	76	46	74	
23	76	52	71	T
24	82	48	80	
25	87	57	80	
26	95	60	87	
27	92	56	84	
28	86	63	78	
29	88	58	69	.03
30	89	55	68	.17
31	80	58	60	.04
			Sum	.75

TABLE XXVII

U.S. WEATHER BUREAU
RECORD OF CLIMATOLOGICAL OBSERVATIONS
STATION--BOULDER, COLORADO
TIME OF OBSERVATION 5:30 P.M.

Date 1967 July	Temp. Boulder 24 Hrs. Ending at Observation Max.	Min.	at Obsn.	Precipitation S. Boulder Ins. & Hundredths
31	88	64	82	
August				
1	89	61	67	
2	89	66	84	
3	84	62	62	.12
4	86	53	65	
5	92	58	80	T
6	82	59	72	T
7	83	59	70	T
8	81	66	69	
9	81	61	65	.02
10	80	53	64	.19
11	82	52	64	
12	88	55	66	.03
13	86	62	83	
14	85	60	70	
15	85	59	75	
16	86	56	64	T
17	86	59	76	T
18	79	57	70	T
19	83	45	75	.76
20	82	56	70	
21	85	54	76	
22	81	61	65	T
23	90	63	87	
24	94	65	75	
25	93	61	78	T
26	77	53	54	
27	90	51	77	.10
28	84	64	72	T
29	82	52	63	T
30	69	52	53	1.83
31	59	48	50	.80
			Sum	3.85

TABLE XXVIII

U.S. WEATHER BUREAU
RECORD OF CLIMATOLOGICAL OBSERVATIONS
STATION--BOULDER, COLORADO
TIME OF OBSERVATION 5:30 P.M.

Date 1968 July	Temp. Boulder 24 Hrs. Ending at Observation Max.	Min.	at Obsn.		Precipitation S. Boulder Ins. & Hundredths	
29	92	59	81			
30	88	64	66		.12	
31	68	50	59		.16	
August				Sum	.28	
1	83	51	80			
2	85	61	83			
3	84	58	75		.02	
4	92	55	84			
5	89	66	81			
6	91	61	84			
7	90	64	80			
8	88	64	82		T	
9	83	60	61		.55	
10	62	53	53	all day	1.53	rain & drizzle
11	76	51	71		.23	
12	82	51	75		.08	
13	84	54	71		.02	
14	72	56	66		.33	
15	83	53	79		.01	
16	83	54	79			
17	81	53	78			
18	83	60	78			
19	86	54	82			
20	88	54	85			
21	86	64	75			
22	85	58	78		T	
23	84	46	81			
24	86	50	74			
25	86	50	85			
26	87	51	82			
27	82	67	72			
28	85	53	75		T	
29	75	50	58		.25	
30	74	44	72		T	
31	75	52	73			
				Sum	3.02	

TABLE XXIX

SOIL MOISTURE
IN QUADRAT 1 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
7/29	1	198.0	7/31	1	185.3	1	12.7	6.85	
	2	193.2		2	178.8	2	14.4	8.05	7.61
	3	190.6		3	176.6	3	14.0	7.93	
7/31	1	202.2	8/1	1	175.3	1	26.9	15.35	
	2	177.1		2	160.5	2	16.6	10.34	12.17
	3	197.6		3	178.3	3	19.3	10.82	
8/1	1	183.9	8/2	1	162.6	1	21.3	13.10	
	2	178.2		2	158.8	2	19.4	12.22	12.93
	3	181.9		3	160.3	3	21.6	13.47	
8/2	1	161.4	8/3	1	146.7	1	14.7	10.02	
	2	206.1		2	190.9	2	15.2	7.96	10.15
	3	208.4		3	185.3	3	23.1	12.47	
8/3	1	203.3	8/4	1	189.4	1	13.9	7.33	
	2	203.0		2	190.8	2	12.2	6.39	6.63
	3	206.3		3	194.3	3	12.0	6.18	
8/4	1	185.0	8/5	1	166.3	1	18.7	11.24	
	2	197.7		2	181.6	2	16.1	8.87	10.66
	3	170.5		3	152.4	3	18.1	11.88	

TABLE XXIX (Continued)
SOIL MOISTURE
IN QUADRAT 1 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/11	1	190.9	8/12	1	158.3	1	32.6	20.59	
	2	195.9		2	160.1	2	35.8	22.36	12.11
	3	194.1		3	157.3	3	36.8	23.39	
8/12	1	176.0	8/13	1	156.0	1	20.0	12.82	
	2	194.4		2	170.0	2	24.4	14.35	14.48
	3	197.2		3	169.6	3	27.6	16.27	
8/13	1	198.3	8/14	1	170.0	1	28.3	16.65	
	2	198.9		2	165.2	2	33.7	20.40	17.73
	3	201.4		3	173.4	3	28.0	16.14	
8/14	1	207.3	8/15	1	178.1	1	29.2	16.40	
	2	192.5		2	163.9	2	28.6	17.45	16.85
	3	182.3		3	156.2	3	26.1	16.71	
8/15	1	190.6	8/16	1	159.8	1	30.8	19.27	
	2	196.8		2	173.1	2	23.7	13.69	15.76
	3	189.3		3	165.6	3	23.7	14.31	
8/16	1	208.5	8/17	1	181.0	1	27.5	15.19	
	2	182.3		2	160.7	2	21.6	13.44	13.94
	3	187.8		3	165.9	3	21.9	13.20	

TABLE XXIX (Continued)
SOIL MOISTURE
IN QUADRAT 1 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/5	1	190.6	8/6	1	174.4	1	16.2	9.29	
	2	191.6		2	176.4	2	15.2	8.62	9.54
	3	208.0		3	187.9	3	20.1	10.70	
8/6	1	207.2	8/7	1	196.6	1	10.6	5.39	
	2	196.8		2	186.8	2	10.0	5.35	5.60
	3	204.5		3	192.8	3	11.7	6.07	
8/7	1	179.2	8/8	1	165.1	1	14.1	8.54	
	2	185.3		2	170.9	2	14.4	8.43	8.58
	3	193.2		3	177.6	3	15.6	8.78	
8/8	1	195.8	8/9	1	184.3	1	11.5	6.24	
	2	193.8		2	183.0	2	10.8	5.90	6.56
	3	206.9		3	192.4	3	14.5	7.54	
8/9	1	193.6	8/10	1	181.3	1	12.3	6.78	
	2	189.1		2	177.4	2	11.7	6.60	6.61
	3	188.4		3	177.0	3	11.4	6.44	
8/10	1	191.8	8/11	1	150.0	1	41.8	27.87	
	2	184.2		2	152.6	2	31.6	20.71	21.93
	3	193.3		3	164.9	3	28.4	17.22	

TABLE XXIX (Continued)

SOIL MOISTURE
IN QUADRAT 1 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/17	1	182.6	8/18	1	163.8	1	18.8	11.48	
	2	196.6		2	169.2	2	27.4	16.19	13.27
	3	203.2		3	181.2	3	22.0	12.14	
8/18	1	203.9	8/19	1	181.3	1	22.6	12.47	
	2	195.8		2	169.2	2	26.6	15.72	14.13
	3	202.7		3	177.5	3	25.2	14.20	
8/19	1	196.9	8/20	1	176.5	1	20.4	11.56	
	2	208.7		2	188.4	2	20.3	10.77	11.84
	3	201.0		3	177.6	3	23.4	13.18	
8/20	1	201.8	8/21	1	183.8	1	18.0	9.79	
	2	206.6		2	184.8	2	21.8	11.80	10.22
	3	204.3		3	187.3	3	17.0	9.08	
8/21	1	191.4	8/22	1	168.6	1	22.8	13.52	
	2	195.6		2	177.9	2	17.7	9.95	11.53
	3	209.1		3	188.2	3	20.9	11.11	
8/22	1	199.6	8/23	1	181.3	1	18.3	10.09	
	2	194.1		2	177.4	2	16.7	9.24	9.40
	3	202.8		3	186.3	3	16.5	8.86	

TABLE XXIX (Continued)

SOIL MOISTURE
IN QUADRAT 1 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/23	1	194.7	8/24	1	173.4	1	21.3	12.28	
	2	208.7		2	189.4	2	19.3	10.19	10.95
	3	200.9		3	182.0	3	18.9	10.38	
8/24	1	204.9	8/25	1	179.1	1	25.8	14.41	
	2	194.7		2	170.4	2	24.3	14.26	13.65
	3	207.4		3	184.7	3	22.7	12.29	
8/25	1	201.4	8/26	1	179.9	1	21.5	11.95	
	2	204.4		2	186.5	2	17.9	9.60	10.90
	3	203.6		3	183.2	3	20.4	11.14	
8/26	1	194.6	8/27	1	183.5	1	11.1	6.04	
	2	208.5		2	194.0	2	14.5	7.47	6.76
	3	201.6		3	188.8	3	12.8	6.78	
8/27	1	191.7	8/28	1	181.7	1	10.0	5.50	
	2	200.0		2	187.2	2	12.8	6.83	6.15
	3	201.5		3	189.9	3	11.6	6.11	

TABLE XXX

SOIL MOISTURE
IN QUADRAT 2 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
7/29	1	134.6	7/31	1	123.2	1	11.4	9.25	
	2	170.0		2	159.9	2	10.1	6.32	7.13
	3	203.4		3	192.2	3	11.2	5.83	
7/31	1	175.8	8/1	1	154.6	1	21.2	13.71	
	2	198.5		2	178.5	2	20.0	11.20	12.01
	3	199.8		3	179.8	3	20.0	11.12	
8/1	1	170.7	8/2	1	158.1	1	12.6	7.97	
	2	142.9		2	129.7	2	13.2	10.10	9.18
	3	158.3		3	144.6	3	13.7	9.47	
8/2	1	194.6	8/3	1	183.7	1	10.9	5.93	
	2	162.7		2	150.6	2	12.1	8.03	7.29
	3	166.4		3	154.2	3	12.2	7.91	
8/3	1	184.1	8/4	1	172.3	1	11.8	6.85	
	2	187.0		2	177.5	2	9.5	5.35	6.63
	3	163.6		3	151.9	3	11.7	7.70	
8/4	1	207.8	8/5	1	189.6	1	18.2	9.60	
	2	170.3		2	154.9	2	15.4	9.94	9.94
	3	172.8		3	156.7	3	16.1	10.27	

TABLE XXX (Continued)
SOIL MOISTURE
IN QUADRAT 2 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/5	1	203.5	8/6	1	192.0	1	11.5	5.99	
	2	200.7		2	187.6	2	13.1	6.98	7.09
	3	199.6		3	184.3	3	15.3	8.30	
8/6	1	181.0	8/7	1	170.1	1	10.9	6.41	
	2	187.7		2	178.7	2	9.0	5.04	6.04
	3	144.2		3	135.2	3	9.0	6.66	
8/7	1	171.5	8/8	1	164.7	1	6.8	4.13	
	2	207.8		2	199.9	2	7.9	3.95	4.24
	3	204.5		3	195.4	3	9.1	4.65	
8/8	1	165.7	8/9	1	159.0	1	6.7	4.21	
	2	207.5		2	199.1	2	8.4	4.22	4.49
	3	180.9		3	172.2	3	8.7	5.05	
8/9	1	166.9	8/10	1	154.1	1	12.8	8.31	
	2	174.9		2	164.5	2	10.4	6.32	7.52
	3	193.0		3	178.8	3	14.2	7.94	
8/10	1	198.1	8/11	1	167.4	1	30.7	18.34	
	2	196.8		2	164.4	2	32.4	19.71	19.46
	3	187.7		3	156.0	3	31.7	20.32	

TABLE XXX (Continued)
SOIL MOISTURE
IN QUADRAT 2 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/11	1	197.7	8/12	1	172.8	1	24.9	14.41	
	2	190.9		2	166.6	2	24.3	14.59	15.21
	3	188.1		3	161.3	3	26.8	16.62	
8/12	1	198.9	8/13	1	159.9	1	39.0	24.39	
	2	194.5		2	161.6	2	32.9	20.36	22.57
	3	180.0		3	146.4	3	33.6	22.95	
8/13	1	185.4	8/14	1	160.0	1	25.4	15.88	
	2	207.5		2	179.6	2	27.9	15.53	15.17
	3	183.0		3	160.4	3	22.6	14.09	
8/14	1	206.6	8/15	1	179.3	1	27.3	15.23	
	2	179.1		2	155.2	2	23.9	15.40	14.78
	3	180.0		3	158.3	3	21.7	13.71	
8/15	1	192.6	8/16	1	162.2	1	30.4	18.74	
	2	194.0		2	163.6	2	30.4	18.58	17.66
	3	198.8		3	171.9	3	26.9	15.65	
8/16	1	174.0	8/17	1	151.8	1	22.2	14.62	
	2	202.0		2	175.5	2	26.5	15.10	15.00
	3	206.7		3	179.3	3	27.4	15.28	

TABLE XXX (Continued)
SOIL MOISTURE
IN QUADRAT 2 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/17	1	194.3	8/18	1	172.6	1	21.7	12.57	
	2	207.0		2	182.6	2	24.4	13.36	13.41
	3	204.6		3	179.0	3	25.6	14.30	
8/18	1	201.9	8/19	1	178.5	1	23.4	13.11	
	2	184.0		2	164.6	2	19.4	11.79	12.41
	3	203.0		3	180.7	3	22.3	12.34	
8/19	1	209.8	8/20	1	189.3	1	20.5	10.83	
	2	199.1		2	181.5	2	17.6	9.70	10.30
	3	194.7		3	176.4	3	18.3	10.37	
8/20	1	183.5	8/21	1	168.0	1	15.5	9.23	
	2	202.9		2	183.6	2	19.3	10.51	10.05
	3	205.6		3	186.2	3	19.4	10.42	
8/21	1	192.4	8/22	1	176.2	1	16.2	9.19	
	2	178.7		2	165.0	2	13.7	8.30	9.45
	3	203.1		3	183.2	3	19.9	10.86	
8/22	1	198.9	8/23	1	184.2	1	14.7	7.98	
	2	204.7		2	188.3	2	16.4	8.71	8.33
	3	204.9		3	189.2	3	15.7	8.30	

TABLE XXX (Continued)
SOIL MOISTURE
IN QUADRAT 2 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/23	1	196.9	8/24	1	182.0	1	14.9	8.19	
	2	198.3		2	183.1	2	15.2	8.30	8.26
	3	191.9		3	177.2	3	14.7	8.30	
8/24	1	209.3	8/25	1	195.5	1	13.8	7.05	
	2	193.0		2	181.2	2	11.8	6.51	6.85
	3	197.8		3	184.9	3	12.9	6.98	
8/25	1	208.2	8/26	1	195.5	1	12.7	6.50	
	2	205.5		2	192.8	2	12.7	6.59	6.88
	3	202.6		3	188.4	3	14.2	7.54	
8/26	1	190.9	8/27	1	180.4	1	10.5	5.82	
	2	186.1		2	175.7	2	10.4	5.92	6.88
	3	176.3		3	161.9	3	14.4	8.89	
8/27	1	205.0	8/28	1	193.3	1	11.7	6.05	
	2	202.1		2	190.8	2	11.3	5.92	6.14
	3	209.7		3	197.0	3	12.7	6.45	

TABLE XXXI
SOIL MOISTURE
IN QUADRAT 3 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
7/29	1	198.1	7/31	1	181.9	1	16.2	8.91	
	2	208.9		2	185.7	2	23.2	12.49	10.28
	3	179.9		3	164.4	3	15.5	9.43	
7/31	1	162.0	8/1	1	140.1	1	21.9	15.63	
	2	188.5		2	159.9	2	28.6	17.89	16.61
	3	204.7		3	176.0	3	28.7	16.31	
8/1	1	191.1	8/2	1	165.6	1	25.5	15.40	
	2	181.1		2	156.4	2	24.7	15.79	15.52
	3	206.4		3	178.9	3	27.5	15.37	
8/2	1	204.1	8/3	1	180.0	1	24.1	13.39	
	2	181.1		2	161.1	2	20.0	12.41	11.61
	3	163.2		3	149.7	3	13.5	9.02	
8/3	1	186.1	8/4	1	169.3	1	16.8	9.92	
	2	191.1		2	171.5	2	19.6	11.42	10.76
	3	176.6		3	159.2	3	17.4	10.93	
8/4	1	204.7	8/5	1	179.6	1	25.1	13.98	
	2	204.4		2	180.2	2	24.2	13.43	13.64
	3	186.6		3	164.4	3	22.2	13.50	

TABLE XXXI (Continued)
SOIL MOISTURE
IN QUADRAT 3 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/5	1	201.0	8/6	1	180.4	1	20.6	11.42	
	2	208.5		2	187.4	2	21.1	11.26	11.36
	3	202.3		3	181.6	3	20.7	11.40	
8/6	1	193.3	8/7	1	177.6	1	15.7	8.84	
	2	195.0		2	174.4	2	20.6	11.81	10.58
	3	191.1		3	172.0	3	19.1	11.10	
8/7	1	204.0	8/8	1	188.6	1	15.4	8.17	
	2	189.7		2	175.6	2	14.1	8.03	8.28
	3	201.5		3	185.5	3	16.0	8.63	
8/8	1	198.8	8/9	1	188.5	1	10.3	5.46	
	2	202.3		2	191.7	2	10.6	5.53	5.35
	3	209.6		3	199.5	3	10.1	5.06	
8/9	1	204.0	8/10	1	182.7	1	21.3	11.66	
	2	203.5		2	189.6	2	13.9	7.33	8.97
	3	203.3		3	188.4	3	14.9	7.91	
8/10	1	186.8	8/11	1	154.8	1	32.0	20.67	
	2	209.4		2	173.1	2	36.3	20.97	20.60
	3	205.7		3	171.2	3	34.5	20.15	

TABLE XXXI (Continued)
SOIL MOISTURE
IN QUADRAT 3 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/11	1	202.7	8/12	1	165.4	1	37.3	22.55	
	2	193.8		2	160.8	2	33.0	20.52	20.59
	3	194.8		3	164.1	3	30.7	18.70	
8/12	1	207.2	8/13	1	169.3	1	37.9	22.33	
	2	200.1		2	164.8	2	35.3	21.42	21.67
	3	200.3		3	165.2	3	35.1	21.25	
8/13	1	182.1	8/14	1	153.8	1	28.3	18.40	
	2	193.8		2	164.1	2	29.7	18.10	19.47
	3	204.0		3	167.6	3	36.4	21.73	
8/14	1	205.3	8/15	1	173.9	1	31.4	18.06	
	2	192.3		2	164.6	2	27.7	16.83	17.09
	3	209.5		3	180.0	3	29.5	16.39	
8/15	1	189.9	8/16	1	159.7	1	30.2	18.91	
	2	157.6		2	133.7	2	23.9	17.88	19.23
	3	165.5		3	136.9	3	28.6	20.89	
8/16	1	201.2	8/17	1	171.8	1	29.4	17.11	
	2	202.5		2	173.4	2	29.1	16.78	17.23
	3	203.9		3	173.1	3	30.8	17.79	

TABLE XXXI (Continued)
SOIL MOISTURE
IN QUADRAT 3 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/17	1	176.6	8/18	1	152.9	1	23.7	15.50	
	2	202.0		2	175.7	2	26.3	14.97	15.39
	3	185.7		3	160.5	3	25.2	15.70	
8/18	1	204.3	8/19	1	180.3	1	24.0	13.31	
	2	192.7		2	170.4	2	22.3	13.09	12.89
	3	180.3		3	160.6	3	19.7	12.27	
8/19	1	207.6	8/20	1	184.0	1	23.6	12.83	
	2	205.3		2	182.5	2	22.8	12.49	12.25
	3	192.2		3	172.5	3	19.7	11.42	
8/20	1	197.6	8/21	1	177.9	1	19.7	11.07	
	2	205.9		2	186.0	2	19.9	10.70	10.94
	3	200.8		3	180.8	3	20.0	11.06	
8/21	1	206.2	8/22	1	186.7	1	19.5	10.44	
	2	178.3		2	164.1	2	14.2	8.65	9.58
	3	206.8		3	188.6	3	18.2	9.65	
8/22	1	202.4	8/23	1	187.1	1	15.3	8.18	
	2	209.2		2	192.8	2	16.4	8.51	8.38
	3	203.1		3	187.3	3	15.8	8.44	

TABLE XXXI (Continued)
SOIL MOISTURE
IN QUADRAT 3 IN 1968

Date	Sample	Wet Soil	Date	Sample	Dry Soil	Sample	Sample Moisture	% Moisture	Average %
8/23	1	195.4	8/24	1	182.3	1	13.1	7.19	
	2	199.1		2	183.8	2	15.3	8.32	7.61
	3	208.1		3	193.9	3	14.2	7.32	
8/24	1	201.9	8/25	1	185.9	1	16.0	8.61	
	2	205.2		2	185.5	2	19.7	10.62	8.53
	3	202.7		3	190.6	3	12.1	6.35	
8/25	1	206.6	8/26	1	196.3	1	10.3	5.24	
	2	198.2		2	187.4	2	10.8	5.76	6.96
	3	209.0		3	190.2	3	18.8	9.88	
8/26	1	204.2	8/27	1	191.5	1	12.7	6.63	
	2	193.5		2	182.4	2	11.1	6.09	6.06
	3	196.8		3	186.6	3	10.2	5.47	
8/27	1	208.4	8/28	1	195.9	1	12.5	6.38	
	2	207.2		2	194.9	2	12.3	6.31	5.85
	3	194.1		3	185.1	3	9.0	4.86	

TABLE XXXII

AVERAGE PER CENT MOISTURE IN ALL QUADRATS IN 1968

Date	Q1		Q2		Q3	
	Daily	Weekly	Daily	Weekly	Daily	Weekly
7/29	7.61		7.13		10.28	
7/31	12.17		12.01		16.61	
8/1	12.93		9.18		15.52	
8/2	10.15		7.29		11.61	
8/3	6.63		6.63		10.76	
8/4	10.66		9.94		13.64	
8/5	9.54	9.96	7.09	8.47	11.36	12.83
8/6	5.60		6.04		10.58	
8/7	8.58		4.24		8.28	
8/8	6.56		4.49		5.35	
8/9	6.61		7.52		8.97	
8/10	21.93		19.46		20.60	
8/11	12.11		15.21		20.59	
8/12	14.48	10.84	22.57	11.36	21.67	13.72
8/13	17.73		15.17		19.41	
8/14	16.85		14.78		17.09	
8/15	15.76		17.66		19.23	
8/16	13.94		15.00		17.23	
8/17	13.27		13.41		15.39	
8/18	14.13		12.41		12.89	
8/19	11.84	14.79	10.30	14.10	12.25	16.21
8/20	10.22		10.05		10.94	
8/21	11.53		9.45		9.58	
8/22	9.40		8.33		8.38	
8/23	10.95		8.26		7.61	
8/24	13.65		6.85		8.53	
8/25	10.90		6.88		6.96	
8/26	6.76	10.49	6.88	8.10	6.06	8.29
8/27	6.15		6.14		5.85	

TABLE XXXIII

ANT COLONY SIZE BY ACTUAL COUNT

Colony	Size	Average
Aphaenogaster (A.) subterranea valida Wheeler	136	
Aphaenogaster (A.) subterranea valida Wheeler	58	
Aphaenogaster (A.) subterranea valida Wheeler	1221	
Aphaenogaster (A.) subterranea valida Wheeler	697	
Aphaenogaster (A.) subterranea valida Wheeler	243	471
Camponotus (T.) vicinus Mayr	7	
Camponotus (T.) vicinus Mayr	61	
Camponotus (T.) vicinus Mayr	230	
Camponotus (T.) vicinus Mayr	62	
Camponotus (T.) vicinus Mayr	142	100
Crematogaster lineolata (Say)	34	
Crematogaster lineolata (Say)	6928	3481
Formica fusca Linnaeus	38	
Formica fusca Linnaeus	85	62
Formica (P.) lasioides Emery	133	
Formica (P.) lasioides Emery	309	221
Formica obscuripes Forel	3330	3330
Formica (N.) pallidefulva Latreille	9	
Formica (N.) pallidefulva Latreille	92	
Formica (N.) pallidefulva Latreille	58	
Formica (N.) pallidefulva Latreille	90	
Formica (N.) pallidefulva Latreille	194	
Formica (N.) pallidefulva Latreille	15	76
Iridomyrmex pruinosus analis (E. Andre)	305	305
Lasius alienus americanus Emery	43	43
Lasius (C.) brevicornis microps Wheeler	70	
Lasius (C.) brevicornis microps Wheeler	141	
Lasius (C.) brevicornis microps Wheeler	141	
Lasius (C.) brevicornis microps Wheeler	82	
Lasius (C.) brevicornis microps Wheeler	56	
Lasius (C.) brevicornis microps Wheeler	117	
Lasius (C.) brevicornis microps Wheeler	710	
Lasius (C.) brevicornis microps Wheeler	524	
Lasius (C.) brevicornis microps Wheeler	230	230
Lasius (A.) claviger coloradensis Wheeler	422	422
Lasius (A.) latipes (Walsh)	43	43
Lasius niger neoniger Emery	1293	
Lasius niger neoniger Emery	87	
Lasius niger neoniger Emery	364	
Lasius niger neoniger Emery	383	
Lasius niger neoniger Emery	138	
Lasius niger neoniger Emery	129	399

TABLE XXXIII (Continued)

ANT COLONY SIZE BY ACTUAL COUNT

Colony	Size	Average
Lasius (C.) umbratus aphidicola (Walsh)	63	
Lasius (C.) umbratus aphidicola (Walsh)	429	
Lasius (C.) umbratus aphidicola (Walsh)	493	
Lasius (C.) umbratus aphidicola (Walsh)	6423	1852
Leptothorax rugatulus Emery	273	
Leptothorax rugatulus Emery	189	231
Liometopum occidentale luctuosum Wheeler	1215	1215
Solenopsis (D.) molesta validiuscula Emery	444	
Solenopsis (D.) molesta validiuscula Emery	281	
Solenopsis (D.) molesta validiuscula Emery	133	
Solenopsis (D.) molesta validiuscula Emery	26	221
Tapinoma sessile (Say)	80	
Tapinoma sessile (Say)	211	147